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Waste Information and Location Database for the OU 7-13/14 Project

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November 2005

Idaho Cleanup Project

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ABSTRACT

This report provides the history of the development and updating of various databases leading to development of the Waste Information and Location Database (WILD). WILD contains the inventory of waste buried in the Subsurface Disposal Area, a radioactive waste landfill located at the Radioactive Waste Management Complex, part of the Idaho National Laboratory. WILD makes available the most current and comprehensive information about waste buried in the Subsurface Disposal Area through June 1997 by linking updated estimates of contaminant inventories and burial locations.

This report presents the method for verification and validation of WILD to enable its use in the comprehensive remedial investigation and feasibility study by Waste Area Group 7, Operable Unit 7-13/14. A data set was taken from WILD on November 29, 2004, to serve as the source term inventory for the Operable Unit 7-13/14 remedial investigation/baseline risk assessment and feasibility study. This particular data set is referred to as the remedial investigation/feasibility study Snapshot. Subsequent modifications to the source term inventory applied to the Snapshot and used in the remedial investigation/feasibility study will be documented in the remedial investigation/baseline risk assessment report.

In addition, this report documents refinement of the waste inventory from the Reactor Technology Complex (formerly Test Reactor Area), enabling this updated information to be included in WILD.

CONTENTS

FIGURES

TABLES

ACRONYMS

ANL-W	Argonne National Laboratory-West (now called Materials and Fuels Complex)
ARC	U.S. Department of Energy Albany Research Center
CIDRA	Contaminant Inventory Database for Risk Assessment
CPP	Chemical Processing Plant (now called Idaho Nuclear Technology and Engineering Center)
DOE-IBO	U.S. Department of Energy Idaho Branch Office (of Pittsburgh Naval Reactors Office)
DU	depleted uranium
EBR	Experimental Breeder Reactor
ECF	Expended Core Facility
EPRI	Electric Power Research Institute
EU	enriched uranium
FY	fiscal year
HDT	Historical Data Task
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
IWTS	Integrated Waste Tracking System
LLW	low-level waste
LMITCO	Lockheed Martin Idaho Technologies Company
MAP	mixed activation product
MFC	Materials and Fuels Complex (formerly Argonne National Laboratory-West)
MFP	mixed fission product
NRF	Naval Reactors Facility
ORIGEN2	Oak Ridge Isotope GENeration and Depletion Code Version 2
OU	operable unit
PWR	pressurized water reactor
RFP	Rocky Flats Plant

RI/BRA	remedial investigation/baseline risk assessment
RI/FS	remedial investigation/feasibility study
RO	roaster oxide
RPDT	Recent and Projected Data Task
RTC	Reactor Technology Complex (formerly Test Reactor Area)
RWMC	Radioactive Waste Management Complex
RWMIS	Radioactive Waste Management Information System
SDA	Subsurface Disposal Area
SWEPP	Stored Waste Examination Pilot Plant
TAN	Test Area North
TRA	Test Reactor Area (now called Reactor Technology Complex)
TREAT	Transient Reactor Experiment and Test Facility
TRU	transuranic
TSA	Transuranic Storage Area
VOC	volatile organic compound
WAG	waste area group
WCF	Waste Calcine Facility
WILD	Waste Information and Location Database
WOS	WasteOScope

Waste Information and Location Database for the OU 7-13/14 Project

1. INTRODUCTION

This report presents the history and reasons for developing the Waste Information and Location Database (WILD) that contains information about radiological and chemical waste buried in the Subsurface Disposal Area (SDA), a radioactive waste landfill located at the Radioactive Waste Management Complex (RWMC), part of the Idaho National Laboratory (INL). WILD makes available the most current and comprehensive information about waste buried in the SDA through June 1997 by linking estimates of contaminant inventories to burial locations. A data set was taken from WILD on November 29, 2004, to serve as the source term inventory for the Operable Unit (OU) 7-13/14 remedial investigation/baseline risk assessment (RI/BRA) and feasibility study (FS). This particular data set is referred to as the remedial investigation/feasibility study (RI/FS) Snapshot. This report reconciles inventory reports to the RI/FS Snapshot. Subsequent modifications to the source term inventory applied to the Snapshot and used in the RI/FS will be documented in the RI/BRA report.

This report also presents methods for verification and validation of this database to enable its use in risk assessment for risk management decisions at the SDA. This verification and validation effort began in April 2004 and is expected to continue through September 2005. By combining data representing the content of the waste streams with data locating the buried waste, this database supports risk assessment and analysis of remedial alternatives being conducted by Waste Area Group (WAG) 7, OU 7-13/14.[a]

In addition, this report documents refinement of the waste inventory from the Reactor Technology Complex (RTC; formerly Test Reactor Area), enabling this updated information to be included in WILD. A summary of this refinement is in the body of this report; for the complete refinement, see Appendix A.

1.1 Purpose

The purposes of this report are to describe development of WILD, to provide the RI/FS Snapshot: a data set taken from WILD as of November 29, 2004, that serves as the source term inventory for the OU 7-13/14 RI/BRA and FS, and to reconcile inventory reports to the RI/FS Snapshot. The information in this report supports risk assessment and analysis of remedial alternatives for the comprehensive RI/FS for OU 7-13/14.

1.2 Scope

To support the RI/FS Snapshot, this report includes:

- A history of changes to the inventories leading to the inventory data in WILD and a description of WILD's additional capabilities beyond earlier databases and reports. Refined estimates are included of radionuclides shipped to the SDA from major facilities at INL and of both radioactive and hazardous waste from the Rocky Flats Plant[b] (RFP). Facilities at INL—evaluated only for

a. The Federal Facility Agreement and Consent Order lists 10 WAGs for INL. Each WAG is subdivided into OUs. The RWMC is identified as WAG 7 and originally contained 14 OUs. Operable Unit 7-13 (transuranic pits and trenches RI/FS) and OU 7-14 (WAG 7 comprehensive RI/FS) were ultimately combined into the OU 7-13/14 comprehensive RI/FS for WAG 7.
b. The Rocky Flats Plant is located 26 km (16 mi) northwest of Denver. In the mid-1990s, it was renamed the Rocky Flats Environmental Technology Site. In the late 1990s, it was again renamed, to its present name, the Rocky Flats Plant Closure Project. Most of the transuranic waste in the Subsurface Disposal Area originated at the Rocky Flats Plant.

radioactive constituents, not chemical constituents—are Test Area North (TAN), RTC, Idaho Nuclear Testing and Engineering Center (INTEC), Naval Reactors Facility (NRF), and Materials and Fuels Complex (MFC; formerly Argonne National Laboratory-West). Chemical inventories for INL generators are taken from previous work (e.g., the Historical Data Task); LMITCO 1995a).

- Methods used to verify and validate the data in WILD.

- A summary of recent evaluations and refinements of the present inventory and locations of waste buried in the SDA.

- Appendix A documents the refinement of radiological inventory from RTC. With the exception of this documentation of refinements for RTC, this report does not contain complete documentation of refinements for facilities that disposed of waste in the SDA. Those inventories are provided in individual reports that are summarized and referenced in this report.

1.3 Overview

Starting in the early 1990s, information about the inventory of hazardous and radioactive materials disposed of in the SDA has been collected and documented in various reports. The Contaminant Inventory Database for Risk Assessment (CIDRA) was developed to manage and provide access to the data from these reports that essentially treated the SDA as a single, homogeneous, source term. Since CIDRA was developed, additional records of disposals have been located and previous records re-examined, making more detailed information available concerning specific waste disposed of in specific pits, high-density areas of materials of concern, and location and contents of individual shipments. These records have been correlated and waste inventories correspondingly refined. These refinements have led to new tables of nuclide inventories and materials of concern that were spread throughout several reports, letters, and memorandums.

The Waste Inventory and Location Database was developed to combine into a single useable database both inventory and detailed locations of the inventory from these documents. In addition to bringing all these data together in a usable form, WILD can be used to collate information and create density maps indicating specific locations of concentrations of materials of concern. Because WILD has been changing and will continue to change through development, validation, and verification, the RI/FS Snapshot was taken, then the data were modified to reflect upcoming changes to WILD to support risk assessment and analysis of remedial alternatives and the comprehensive RI/FS. This report reconciles the inventory estimates for use in the RI/FS with the RI/FS Snapshot. Modifications to the source term inventory subsequent to the Snapshot and used in the RI/FS will be documented in the RI/BRA report.

1.4 Brief History and Description of the Idaho National Laboratory

Originally established in 1949 as the National Reactor Testing Station, INL is a DOE-managed reservation that has historically been devoted to energy research and related activities and is located in southeastern Idaho, occupying 2,305 km^2 (890 mi^2) in the northeastern region of the Snake River Plain. Regionally, INL is nearest to the cities of Idaho Falls and Pocatello and to U.S. Interstate Highways I-15 and I-86. The INL Site extends nearly 63 km (39 mi) from north to south, is about 58 km (36 mi) wide in its broadest southern portion, and occupies parts of five southeast Idaho counties. Public highways (i.e., U.S. 20 and 26, and Idaho 22, 28, and 33) located within the boundary of INL are accessible without restriction. See Figure 1 for the location of INL and of the major facilities (Holdren et al. 2002).

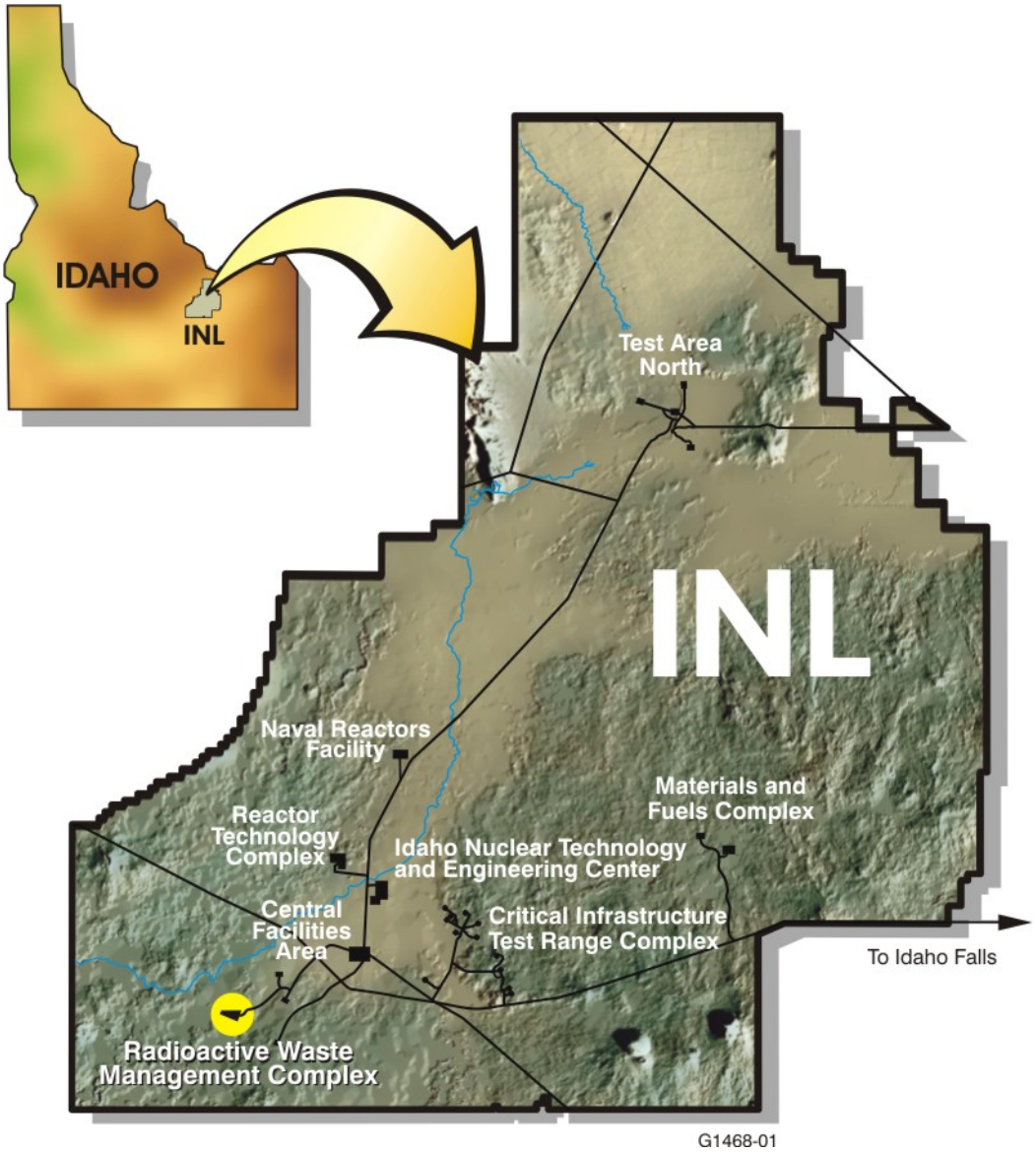

Figure 1. Location of the Radioactive Waste Management Complex and other major facilities at the Idaho National Laboratory.

Located in the southwestern quadrant of INL, RWMC encompasses a total of 72 ha (177 acres) and is divided into three separate areas by function: the SDA, the Transuranic Storage Area (TSA), and the administration and operations area. The original landfill, established in 1952, covered 5.2 ha (13 acres) and was used for shallow land disposal of solid radioactive waste. In 1958, the landfill was expanded to 35.6 ha (88 acres). Relocation of the security fence in 1988 to outside the dike surrounding the landfill established the current size of the SDA as 39 ha (97 acres). Located adjacent to the east side of the SDA; TSA was added to RWMC in 1970; encompasses 23 ha (58 acres); and is used to store, prepare, and ship retrievable transuranic waste to the Waste Isolation Pilot Plant. The 9-ha (22-acre) administration and operations area at the RWMC includes administrative offices, maintenance buildings, equipment storage, and miscellaneous support facilities (Holdren et al. 2002). See Figure 2 for a map of RWMC showing the location of the SDA.

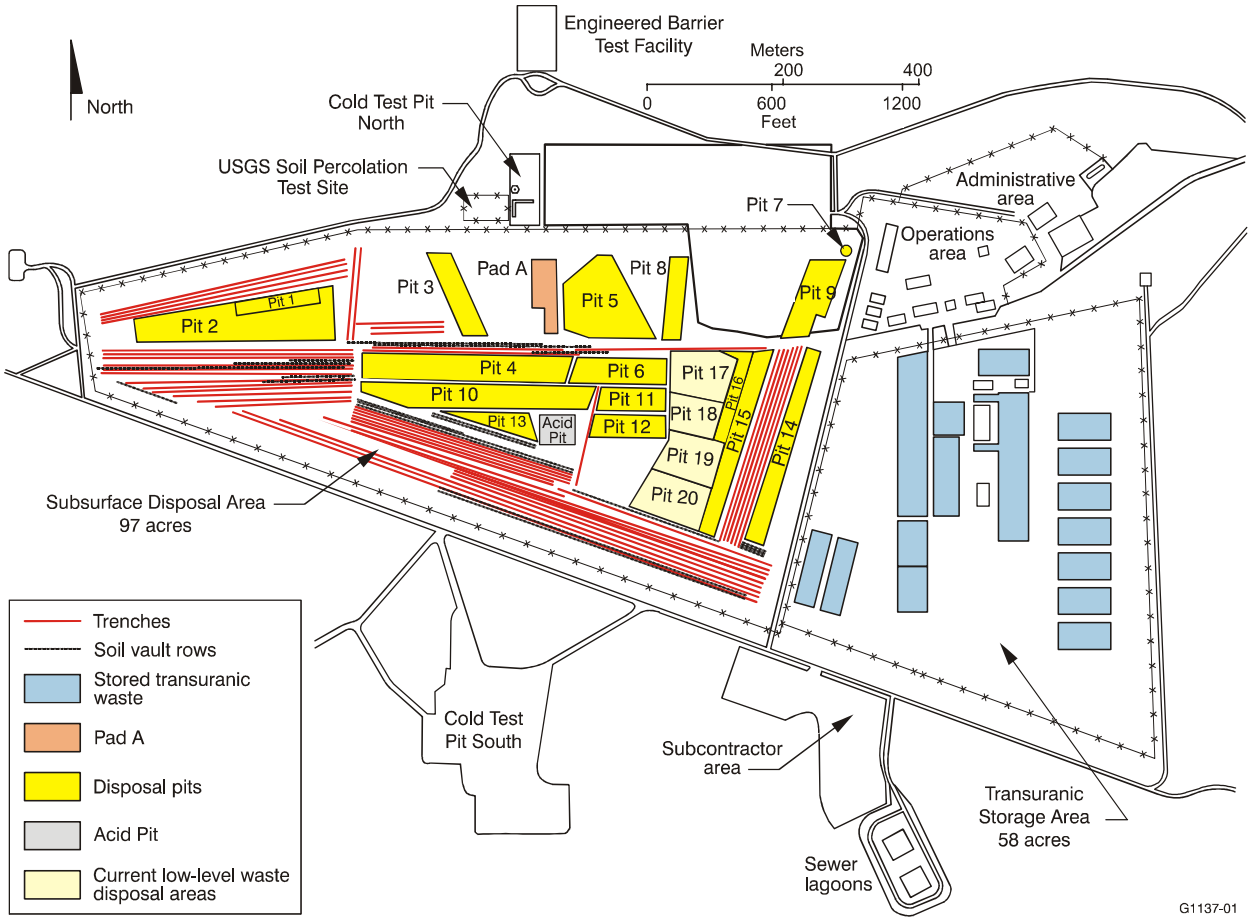

Figure 2. Map of the Radioactive Waste Management Complex showing the location of the Subsurface Disposal Area.

1.4.1 Brief History of the Subsurface Disposal Area

The SDA is a radioactive waste landfill with shallow subsurface disposal units consisting of pits, trenches, and soil vaults. Contaminants in the landfill include hazardous chemicals, remote-handled fission and activation products, and transuranic (TRU) radionuclides. Waste acceptance criteria and record-keeping protocols for the facility have changed over time in keeping with waste management technology and legal requirements. Today's requirements are much more stringent as a result of knowledge developed over the past several decades about potential environmental effects of waste management techniques. Previously, however, shallow landfill disposal of radioactive and hazardous waste was the conventional disposal technology.

Construction, operation, and decommissioning of INL nuclear reactor testing programs have resulted in large volumes of waste. Various containers were used in shipping and disposing of the waste, including steel drums (30-, 40-, and 55-gal), casks, cardboard cartons, and wooden boxes (as large as 105 × 105 × 214 in.). Larger individual items—such as tanks, furniture, process and laboratory equipment, engines, and vehicles—were placed separately as loose trash. Additionally, liquid waste was disposed of in the SDA, including direct disposal of free liquids to the pits and trenches and disposal of solidified liquids in containers.

Radioactive waste from off-INL sources originated from a variety of facilities, including military and other defense agencies, universities, commercial operations, and the Atomic Energy Commission. The primary off-INL contributor was RFP, which shipped TRU waste to the SDA between 1954 and 1970. In 1957, using pits for RFP waste was instituted. Initially, waste was stacked in pits and trenches. However, beginning in 1963, some waste was dumped to reduce labor costs and minimize radiation exposure of personnel. Current disposal operations stack contact-handled waste to maximize disposal capacity of the landfill. Remote-handled waste is placed in either concrete vaults or the bulk storage area.

1.4.2 Geophysical Description

Underlying RWMC at an approximate depth of 177 m (580 ft), the Snake River Plain Aquifer flows generally from the northeast to the southwest. The aquifer is bounded on the north and south by the edge of the Snake River Plain, on the west by surface discharge into the Snake River near Twin Falls, Idaho, and on the northeast by the Yellowstone basin. The aquifer consists of a series of water-saturated basalt layers and sediment.

The SDA is a semi-arid sagebrush desert; the subsurface below a shallow (approximately 0.6 to 7.0 m [2 to 23 ft]) soil horizon is characterized by alternating layers of fractured basalt and sedimentary interbeds. The regional subsurface consists mostly of these layered basalt flows with a few comparatively thin layers of sedimentary interbeds. The interbeds tend to retard infiltration to the aquifer and are important features in assessing the fate and transport of contaminants. Infiltration of water occurs episodically from rain and snowmelt. The soil horizon is unsaturated most of the year and the underlying formations are characterized as a vadose zone (Holdren et al. 2002).

1.5 Document Organization

The following list briefly describes the remaining sections in this report.

- Section 2 gives a brief history of the databases and provides documentation of waste inventories and the implementation of WILD.
- Section 3 summarizes the major contribution to waste streams and total curies by facility.
- Section 4 describes the refinements and partitioning of the inventory by facility.
- Section 5 describes development of the RI/FS Snapshot.
- Section 6 lists the references cited throughout this report.
- Appendix A presents the updated estimate of inventory from RTC.
- Appendix B summarizes updated refinement of radiological and chemical inventories in the RI/FS Snapshot.
- Appendix C summarizes updated estimates of radioactive inventory by waste streams in the SDA.
- Appendix D contains an e-mail from Becker to McKenzie that summarizes RFP inventory corrections.
- Appendix E contains an e-mail from Fuhrman to Becker that confirms an improved chlorine-36 estimate for U.S. Bureau of Mines disposals.

- Appendix F contains a letter from Swenson to McKenzie that discusses disposal of Waste Calcine Facility (WCF) off-gas filters.

- Appendix G contains a letter from Soule to Lee discussing waste shipped to the National Reactor Testing Station (original term for INL).

2. IMPLEMENTATION OF WASTE INFORMATION AND LOCATION DATABASE

WILD records inventories of waste buried at the SDA. Records have been kept since the SDA's inception in 1952, but the inventory systems have changed over time as technology improved the ability to keep and retrieve information.

The following four databases at INL have historically housed information about waste buried in the SDA. Of the four, only the last listed below is still active; the first three—created to contain different kinds of information about waste buried in the SDA—have been archived and their data merged into WILD. Thus, WILD houses all available data for years preceding June 1997, and Integrated Waste Tracking System (IWTS) houses data from June 1997 through the present.

- Radioactive Waste Management Information System (RWMIS): an archived database (from 1971) housing data for SDA waste disposals from 1954 through June 1997. Data were entered from data entry forms by administrators of the database. RWMIS contained increasing levels of detail:
  - 1954 through 1970—totals of disposal data by year
  - 1971 through 1985—totals of disposal data by shipment
  - 1985 through 1997—totals of disposal data per container; post-1985—a limited set of physical, chemical, and radiological characterization data for each container.
- Contaminant Inventory Database for Risk Assessment: an archived database (deployed in 1995) that housed data combining inventories of both radiological and non-radiological contaminants buried in the SDA. CIDRA is the electronic documentation of inventories developed in the HDT and Recent and Projected Data Task (RPDT).
- WasteOScope (WOS): an archived database that merges RWMIS data with information from transcribed hard-copy shipping documents (e.g., Form 110s). WasteOScope tied geographic burial locations in the SDA to shipment locations defined in the hard-copy shipping documents or in RWMIS, thus enabling maps to be generated by the Geographic Information System (GIS) that show disposal locations in the SDA. Other than physical information (i.e., shipment volumes, weights, container counts), WOS contains no characterization data by waste stream of chemical or radiological constituents.
- Integrated Waste Tracking System: an active database (from November 1996) that is managed by Waste Generator Services. This database houses the container-level data for SDA waste disposals from June 1997 to the present, including continuing disposals in the pits remaining open today. IWTS documents a set of physical, chemical, and radiological characterization data for each container disposed of at the RWMC. While these data are sufficient to comply with regulatory requirements for transportation and disposal, in some cases the data are not sufficient to support the RI/BRA. Data are entered by Waste Generator Services personnel trained in the complexities of waste characterization.

Because all four databases were built on different software platforms and had varied quality of data and varied levels of configuration management, retrieval of data was inefficient and information supplied to OU 7-13/14 projects about buried waste was inconsistent. Therefore, the Buried Waste Information Project was established to reach two main objectives:

- Single-source access of information about waste buried at RWMC to allow fast, efficient, and consistent retrieval of data to support current and future OU 7-13/14 projects.

- Verification, validation, and configuration management of information about waste buried at RWMC to ensure a high level of confidence in the accuracy and consistency of data supporting current and future OU 7-13/14 projects.

Single-Source Data Access. Due to the complexity of IWTS, single-source data access for all information about waste buried in the SDA was not feasible. Therefore, IWTS continues to provide information about waste disposed of after June 1997. In order to replace RWMIS, CIDRA, and WOS, data from these three databases were moved into WILD to provide a single source for pre-1997 shipments to the SDA and allowing these three databases to be retired. Data are housed in WILD for all waste disposed of in the SDA before June 1997; WILD makes accessible all previous information about the waste (e.g., geographic location, curie count per container, waste streams, and chemical and radiological contaminants of interest).

In addition, WILD links radioactive source term inventory to disposal locations and supplies data to the SDA Map Builder Application, allowing "density mapping," a technique that creates maps showing burial locations of specific contaminants or objects, locations of monitoring devices, or other information specifically queried.

Project personnel, via the Buried Waste Information Web-site, can access the WILD data set. Data in WILD are retrieved either by a Reporting Service or an Interactive Map of the RWMC SDA.

Verification and Validation. Verification and validation of SDA buried waste information is essential to ensure that accurate data are available to support remedial investigative and design work. However, the initial movement of data from WOS to WILD proved to have an excessive rate of errors; thus, a one-for-one validation of the WILD data set against source documents became required. This verification and validation effort for the WILD data set began in April 2004 and is expected to continue through September 2005.

2.1 Brief History of Databases and Reports Detailing Waste Inventory

Over time, waste disposals have been documented in accordance with changing requirements and objectives. In the 1950s and 1960s, the primary objective was to protect workers who handled waste. That objective grew to include long-term environmental concerns, leading to stricter requirements in the 1970s for radioactive materials, and in the 1980s for chemical contaminants. Along with changing requirements, record-keeping practices were modified with advancing technology. For example, early records were in the form of logbooks and handwritten forms, but today, containers are labeled with bar codes and disposal records are stored and maintained electronically.

Over the past ten years, risk assessments and analyses of alternatives to mitigate unacceptable risks have relied on the four databases listed above and two reports. These databases and reports are summarized in the sections that follow. See Figure 3 for a chart showing the relationship among the various sources that have fed information into WILD.

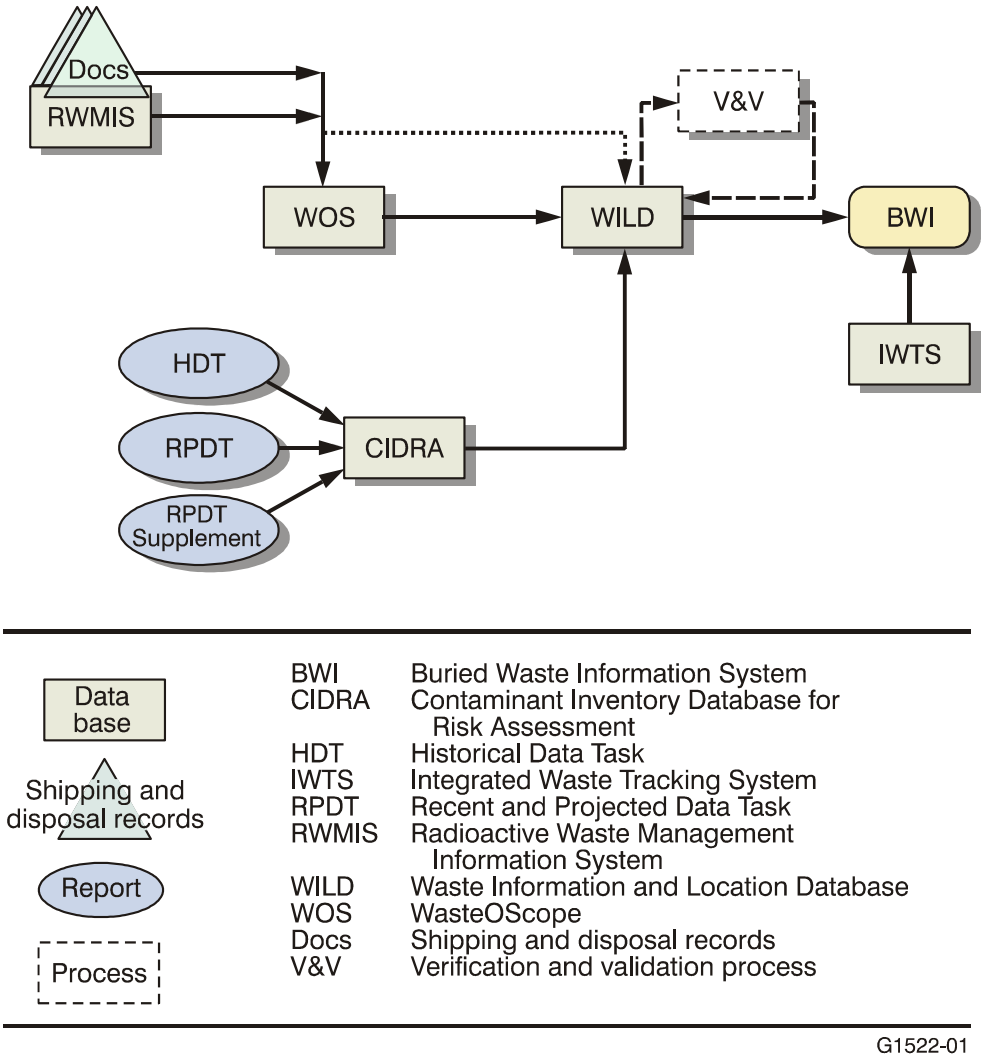

Figure 3. Illustrates the various forms, reports, and databases that have fed information into the Waste Information and Location Database. The dotted line indicates revisiting earlier shipping and disposal records and the Radioactive Waste Management Information System for more detail. This additional detail was included in the Waste Information and Location Database.

2.1.1 Radioactive Waste Management Information System

The RWMIS database was developed in 1971 as the official INL record for solid radioactive waste stored, disposed of (TRU[c], mixed, and low-level waste), or sent for size reduction and processing (TRU, low-level waste, and mixed) at INL through June 1997. The system was designed and implemented using

c. Because the definition of TRU waste changed in 1982, it is important to note that a large portion of the waste previously designated TRU is not TRU by today's definition. Originally, TRU waste was defined as all waste contaminated with TRU radionuclides in concentrations greater than 10 nCi/g (AEC 1973). However, in 1982, TRU waste was redefined (DOE Order 5820.1) as waste materials containing any alpha-emitting radionuclide with an atomic number greater than 92, a half-life longer than 20 years, and a concentration greater than 100 nCi/g at the end of the period of institutional control as defined in DOE M 435.1-1, "Radioactive Waste Management Manual."

the COBOL[d] computer programming language. In 1982, the COBOL system was converted to NOMAD, and, in 1996, the system was converted to ORACLE.

Records in 1971 were available for annual volumes and curies of solid radioactive waste disposed of at the RWMC from 1961 to 1970. Also available were annual volumes of RFP waste disposed of from 1954 to 1970. Before late 1970 when the TSA opened, no details regarding the nuclides of RFP shipments had been provided. As a result of a special process for material accountability and reconciliation, annual nuclides and gram quantities of RFP waste were provided and incorporated into the RWMIS summary tables. These values were provided, not on a detailed nuclide basis, but on a generic nuclide basis.

From 1952 to 1960, waste was disposed of at RWMC from sources other than RFP. These data were entered into the annual reporting in 1971 as a lump sum under the RWMC. These annual numbers were placed in the RWMIS in a summary table. Official reports were generated from this annual RWMIS summary table and the 1971 to 1997 detailed data records.

Detailed data on solid waste from 1954 to 1970 were included in RWMIS in approximately 1976 (this database is referred to as "very old" RWMIS). These detailed data were obtained from RWMC logbook records and available shipping documents. During this period, both TRU and non-TRU waste were being received at RWMC. For the 1954 to 1970 period, these waste types were not reported separately. Therefore, the 1954 to 1970 detailed data file was reliable only for disposal location, gross volume, and gross curies, not for detailed nuclide or curie analyses. Records were not found for several pits and trenches. Because of the uncertainty and incompleteness of the detailed solid waste data for 1954 to 1970, detailed data on solid waste from these years were not included in the active reporting database files.

2.1.2 Historical Data Task and Recent and Projected Data Task Reports

Two reports—HDT (LMITCO 1995a) and RPDT (LMITCO 1995b)—compile the SDA radioactive and chemical inventories. HDT covers the period from 1952 through 1983; RPDT covers from 1984 through 1993 and includes projections through 2003. The period was subdivided because of major changes in criteria for waste disposal that became effective in 1984, but methodologies and objectives for developing the two reports were the same. Neither report tied radiological inventory to disposal location.

These two reports were prepared to satisfy site characterization requirements for the baseline risk assessment under CERCLA. The initial information source for both HDT and RPDT was RWMIS. Data in RWMIS were sufficient for transportation and disposal of waste at the SDA, but not sufficient to support the RI/BRA effort. To improve RWMIS data, teams were assigned to each of the six significant waste generators to reconstruct disposal histories by reviewing waste-generating processes and disposal practices that sent waste to the SDA. A seventh category, other generators, compiled similar information for minor contributors.

2.1.3 Contaminant Inventory Database for Risk Assessment Database

The Contaminant Inventory Database for Risk Assessment was an electronic version of data developed in HDT, RPDT, and the RPDT Supplement (Little et al. 2001). Information was imported into database software: first in Lotus 1-2-3, then FoxPro, then Access, to facilitate manipulating the data for

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d. References herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government, any agency thereof, or any company affiliated with the Idaho National Laboratory.

use in risk assessment modeling. The database was queried for contaminants of interest, and necessary data were downloaded into formats appropriate for input for the model being implemented. Modeling based on CIDRA for the Interim Risk Assessment (Becker et al. 1998) revealed several apparent anomalies in waste inventories, which led to additional inventory investigations. These investigations concluded with modifications to inventories. However, CIDRA itself was not modified; instead, input files for the models were changed.

2.1.4 Supplement to the Recent and Projected Data Task Document

The RPDT Supplement (Little et al. 2001) replaced projections with actual disposal data for 1994–1999. Waste disposal data were compiled from the IWTS database (the system that replaced RWMIS in 1997 and is still in use today). However, reported radioisotopic profiles, though consistent with reporting requirements, did not provide sufficient detail for long-term risk assessment. Therefore, waste-generating processes were examined and appropriate adjustments were identified and documented.

2.1.5 Inventory Update Documents

Anomalies revealed by attempts to calibrate source release and fate and transport models, discovery of additional records, and expanded information about waste generating processes prompted additional verification of inventories sent to the SDA. These efforts have focused on contaminants of potential concern identified in the interim risk assessment (Becker et al. 1998). Work that has been completed includes validating radionuclide inventories for TAN (Studley et al. 2004), INTEC (Vail, Carboneau, and Longhurst 2004), MFC (Carboneau and Vail 2004), NRF (Giles, Holdren, and Lengyel 2005), RTC activation products (Logan 1999), and inventories of volatile organic compounds (VOCs) from RFP (Miller and Varvel 2005; Varvel 2005).

Confidence in inventory data has been substantially improved. Reviews have found a few significant changes to inventories reported in the HDT and RPDT. Most notable are modifications to CCl_4 from RFP and C-14 from RTC. In general, however, most modifications have not been significant.

2.1.6 Integrated Waste Tracking System

The IWTS is a client-server application implementing a Sybase data structure and a PowerBuilder front end. The IWTS was deployed in November 1996 to accommodate the collection of mixed-waste data for the development of the INL Site Treatment Plan. Detailed information is documented in IWTS at the container-level for physical, chemical, and radiological parameters commensurate with transportation and disposal requirements. In June 1997, IWTS replaced RWMIS as data repository for low-level waste (LLW) data, including SDA disposal information.

2.1.7 WasteOScope Database

In addition to reconstructing and validating inventories, recent efforts also have addressed shipment disposal locations and improving precision in location data to map contaminants in the SDA. Inventories are now being assigned to individual shipments, enabling OU 7-13/14 to map locations containing the highest concentrations of contaminants and waste streams of interest.

The first application that documented RFP load lists linking the shipping information to disposal information was called WasteOScope (WOS) (White and Tedrow 2002; Potelunas, White, and Tedrow 2002). This was an application of DOE Albany Research Center (ARC)View (ARCView) 3.2 that contained the shipping records for Trenches 1 through 58, Soil Vault Rows 1 through 20, Pad A, Pits 1 through 6, and Pits 8 through 10. WasteOScope allowed searching the disposal database to locate

disposals of interest and to view the location. ARCView 3.2 has some data manipulation capability, but it is limited. In addition, ARCView 3.2 cannot handle the amount of data that would ultimately be loaded into the database and linked to the inventory data. Therefore, the information in WOS was incorporated in WILD.

3. SUMMARIES OF MAJOR CONTRIBUTIONS TO WASTE STREAMS AND TOTALS OF CURIES

The following sections summarize reports of refinements of waste streams shipped to the SDA from major facilities at INL and from RFP. Facilities at INL are TAN, RTC, INTEC, NRF, and MFC. See Section 4 for partitioning information.

3.1 Test Area North

A refinement of radiological inventory from TAN from 1960 through 1993 verified data and presented the methodology by which the data were developed (Studley et al. 2004). The following information is condensed from that report. Refinements and partitioning to individual shipments are addressed in Section 4; nuclide waste stream summaries are in Appendix C.

3.1.1 Waste Stream Assessment

Original estimates generated from CIDRA contained gaps in the amount of contaminants discharged from TAN. Two of INL data-managing systems—RWMIS and the OU 7-13/14 project files—used in this refinement also proved to be incomplete as sources of data for estimating complete nuclide-specific breakdown of contaminants of interest. Documentation in these sources usually included activation products, fission products, as well as actinides and TRU waste.

The HDT listed 28 waste streams from TAN for 1960 through 1983, and the RPDT listed 22 waste streams from TAN for 1984 through 1993. These waste streams were not directly connected to any transportation shipments to the SDA during these periods. To link waste streams to shipments required the following four pieces of information:

- Place of origin (identified by the waste stream number)
- Year(s) generated (based on the HDT and RPDT)
- Project origin (identified by shipment number)
- Year of disposal (part of the shipment number).

3.1.2 Data Analysis

Inventories, level of agreement, and actual data or improved estimates were compared using four main sources of information about TAN waste: (1) HDT Report, (2) RPDT Supplement, (3) OU 7-13/14 Project file shipping documents, and (4) RWMIS database.

3.1.2.1 ***Analysis Approach.*** Data from TAN were analyzed in four phases:

- Evaluation and comparison of inventories developed from RWMIS and Form 110 (AEC Form 110, 1964, “Waste Disposal Request and Authorization”) with those presented in the RPDT
- Identification of waste shipment inventories resulting in a curie load per year greater than 80% of the total curies disposed of

- Assessment of inventories from the TAN processing facility and SDA disposal facility to confirm total amounts of curie load at disposal locations

- Evaluation of inventories to determine waste forms that may affect options for remediation.

3.1.2.2 Waste Shipment Analysis. To quantify the inventories, data were collected from shipping manifests from the generating facilities at TAN and from manifests showing disposal locations (from RWMIS).

TAN shipping manifests covered 1960 through 1984; inventories of disposal locations (from RWMIS) covered 1962 through 1993. Data from both were entered in spreadsheets to create the basis for evaluation using shipping volume (m^3), weight (kg), and gross radioactivity (Ci). These spreadsheets were created shipment-by-shipment, and included shipping and disposal dates, disposal locations, and isotopic waste profiles whenever available.

3.1.3 Overview of Methodology

For reevaluating the radiological content of the waste, a uniform methodology was applied to re-derive the breakdown of radiological content for all shipments from 1960 to 1983. For waste shipped from 1984 to 1993, a model recalculated the activities of radionuclides important to risk assessment.

Several pieces of information on the waste shipment forms helped derive the isotopic breakdown: origin of the waste (e.g., "GE-ANP," referring to the General Electric Aircraft Nuclear Propulsion Program, date of shipment, total curie content, and composition; e.g., metal or fuel specimen). The name of the program that generated the waste often identified the reactor that was the originator, the listed composition offered some clue as to which reactor component gave rise to it, and the date of shipment provided a time frame following the end of reactor operation that was used to make decay corrections for radionuclide contents. The total curie content on the waste shipment forms served as a normalization constant for the radionuclide breakdown.

The radioactive isotopic ratios were obtained through calculations using Oak Ridge Isotope GENeration and Depletion Code Version 2 (ORIGEN2) (Croft 1980) for the in-reactor irradiation of materials (generally, 1 lb of material), based on the operating history of the reactor that is considered most probable to have produced the radioactive isotopes. The activities were decay-corrected to the date of shipment.

To arrive at the activities of individual isotopes, an ORIGEN2 model was identified for each shipment, and isotopic ratios of that model were applied to the total curie content for that shipment.

For years 1984 to 1993, documented shipment of total activities appears to have included only important radionuclides (e.g., Co-60 and Cs-137), and the total for a given year was often the sum of radionuclides listed. Therefore, in the new calculation of the breakdown into individual radionuclides, the sum of the fractions of important radionuclides was normalized to 1. Isotopic contents were calculated using spreadsheet programs.

3.1.4 Calculation Process and Description of Models

The process of calculating isotopic contents in a waste shipment started with identifying the origin of the waste from information on the waste shipment forms. Then a model was constructed for generation of the isotopes from in-reactor irradiation. The model included reactor type (e.g., fast or thermal), fuel and fuel cladding composition, irradiation time, and decay time since the end of irradiation.

The activity ratio of individual radionuclides to total activity in the irradiated mass was applied to total activity in the waste shipment to arrive at activities of individual radionuclides in the waste shipment. Exceptions to this ratio determination were those for the mixed fission product (MFP) model, and the post-1983 radionuclide model. For the MFP model, ORIGEN2 calculated irradiated fuel with cladding. Since the waste was identified as containing MFPs, isotopic ratios were calculated based on total curie contents of fission products and actinides only. For the post-1983 model, the sum of ratios of important radionuclides was normalized to 1. For each shipment year, activities were decayed from shipment date to December 31 of that year. For shipments from 1960 to 1993, 18 models were constructed to arrive at 18 sets of isotopic ratios.

3.1.5 Disposal Waste Stream and Model Relationship

An isotopic model was identified for each waste stream shipped in a particular year. The type of waste was divided into two categories: metal and debris. For risk assessment purposes, it was assumed that the metal waste matrix provided an initial barrier to radioisotope migration until the matrix was corroded, but that the debris waste matrix provided no barrier to radioisotope migration. Descriptions of material in the shipments were based on information in shipment papers.

3.1.6 Uncertainty Estimates

A rigorous analysis of uncertainties of the quantities of activities shipped from TAN was not possible due to lack of information on the basis of reported activities. The assumption was made that total reported activity had an uncertainty (at the one-sigma level) not more than a factor of 2. Ratios for isotopic breakdowns calculated probably have an uncertainty somewhat less than a factor of 2, based on experience with isotope generation and depletion calculations. When these two sources of uncertainty are combined, uncorrelated, the total uncertainty would be a factor between 2 and 3 (Studley et al. 2004).

3.1.7 Conclusions

Review of the OU 7-13/14 Project file and RWMIS database showed that TAN generated 9.72E+03 m^3 of waste containing 6.64E+04 Ci. Limitations of historical documents were a major difficulty in making this refinement (i.e., working “backward” from known projects and programs and records in the RPDT and HDT, and taking into account that not all waste sent to the SDA was generated directly from TAN facilities, although this waste was included in TAN waste streams). Because of their size and design capabilities, the Hot Cell and Hot Shop (TAN 607 and 633) received materials from other Site areas and from off-INL locations for disassembly and inspection; therefore, materials and debris generated from this work were a large part of materials eventually shipped to the SDA.

3.2 Reactor Technology Complex

This section for RTC is summarized from the refinement provided in Appendix A. In previous analyses of the waste shipments, the breakdown of nuclides was estimated by applying nuclide ratios based on the presence of certain flag nuclides. These estimates were based on nuclide breakdown ratios from the analysis of pressurized water reactor (PWR) commercial power reactors using Electric Power

Research Institute (EPRI) scaling factors, which do not take into account the differences between RTC test reactors and commercial power reactors used by EPRI. These differences include metallurgical makeup of core materials, operating power levels, neutron flux levels, and densities. However, Logan's (1999) assessment of RTC waste shipments is based on an engineering analysis and ORIGEN2 models that establish nuclide breakdowns unique to RTC reactors for the core component, MFP, and mixed activation product (MAP) as discussed in Appendix A.

Breakdowns in Logan (1999) were applied to available information and resulted in curie values for individual waste shipments from TRA. For reactor core components, this allowed a more detailed breakdown of nuclides present in these materials. The new inventory also includes nuclides not reported in the original inventory because they have no EPRI scaling factors. Additionally, this assessment estimated the amount of chlorine contamination in some RTC reactor components that generate chlorine-36 when subjected to a neutron flux.

Refinements and partitioning to individual shipments are addressed in Section 4. Nuclide waste stream summaries are in Appendix C.

3.2.1 Conclusion

The refinement indicates that carbon-14 reported in the existing inventory is an overestimate. Because of improvements in the methods used to estimate nuclide breakdown, the estimate made in this refinement is more defensible. This refinement allows nuclide breakdown to be estimated based on an estimate of the mass of materials disposed of in the waste shipment. Using waste mass for core components will generate differences in reported nuclide inventories. Additionally, since ratios of nuclides in MAP for RTC are different from commercial PWR ratios, a better estimate of the MAP nuclide breakdown can be made where gross curies are the only data available.

See Appendix A for summary data of RTC nuclide breakdown by waste stream.

3.2.2 Uncertainty

The uncertainty used to establish the maximum and minimum values for the RTC assessment is +/- 30%. These uncertainties are based on analysis documented in Logan (1999). No additional analysis of uncertainties was performed.

3.3 Idaho Nuclear Technology and Engineering Center

A refinement of radiological inventory from INTEC published by Vail, Carboneau, and Longhurst (2004) verifies data and presents the methodology by which the data were developed. The following information is condensed from Vail, Carboneau, and Longhurst. Refinements and partitioning to individual shipments are addressed in Section 4; nuclide waste stream summaries are in Appendix C.

Formerly known as the Idaho Chemical Processing Plant (CPP), INTEC was chartered in 1953 to reprocess spent nuclear fuel for recovery and recycling of fissile uranium. Fuel reprocessing at INTEC began in 1953 and continued until April 1992. Most fuel that was reprocessed originated from several different facilities in the DOE complex. During those years, about 32 metric tons of highly enriched, reprocessed fuel was produced (Lewis et al. 2000).

The current mission of INTEC is to receive and store spent nuclear fuels and radioactive waste, treat and convert waste, and develop new technologies for waste management for DOE. Facilities at INTEC once dedicated to reprocessing work are being converted to safe and stable shutdown while waiting for reuse or deactivation, decontamination, and decommissioning.

Although waste streams originally identified for this period were complete, the distinction between high-activity and low-activity waste streams was not always clear in some of those original definitions. In redefining those waste streams, solid, low-activity, general plant waste streams were separated from higher-activity waste streams consisting of fission products or activation products. These low-activity waste streams had only traces of fission, actinide, and activation products. Where possible, higher activity waste streams were combined with others having similar contaminant profiles. In a number of other cases, waste streams were renamed for administrative reasons (for example, the original CPP prefix has been superseded by INTEC).

Three main radiological contaminant categories are associated with this period: fission products, trace activation products, and trace actinide contaminants. From 1984 through 1993, operations at INTEC included receiving expended fuel for storage, fuel reprocessing, and processing liquid raffinates into calcine. Disposal practices from 1984 through 1993 were relatively uniform.

Generally, refinement of data for this period indicated that original waste streams included were reasonably complete. However, to develop updated isotopic profiles more efficiently, waste stream descriptions were redefined using methods similar to those used for the HDT period.

3.3.1 Data Collection and Analysis

For general data collection, any available documentation was reviewed that was pertinent to SDA disposal operations. This documentation fell into two categories: the first category included shipping manifests or electronic databases that contained SDA disposal information; the second category included documents containing process information connected with disposals.

Data were collected from available sources and entered into Excel spreadsheets, organized by year. Each waste shipment had a separate data entry, including date and location of the disposal, the general contents (using a numerical waste stream identification code), and shipping container (using a numerical container identification code). Accompanying these entries were estimates of net activities. Generally, these net activities were accompanied by other, more isotope-specific, activities. However, the fission products reported for each shipment were generally limited to activities for such contaminants as Cs-137 and Sr-90; other contaminants of interest, such as Tc-99 and I-129, were not included.

3.3.2 Uncertainties

Because of the highly variable and shipment-dependent nature of many of the waste streams, standard statistical uncertainty methods were not feasible. As in the original comprehensive reports (LMITCO 1995a and 1995b), the methodology for defining best-estimate activities and associated upper and lower bounds was not based on a rigorous model for statistical error propagation, but rather on approximation methods based on professional judgment and reasonable assumptions. A similar approach is applied for this assessment. Upper-bound values represent the error factors that are multiplied to produce an upper bound and are divided to produce a lower bound. This method presents a proportional uncertainty rather than a balanced uncertainty that is possible with measured results. With large uncertainties that are judgment-based, this is the best representation of uncertainty.

3.3.3 Conclusions

Almost 98% of the 2.8E+05 total curies contained in the waste are represented by only three isotopes: Co-60 from Experimental Breeder Reactor (EBR)-II-activated hardware represents 57% of the total; Sr-90 and Cs-137 from the Vycor glass disposals represent 20% and 21%, respectively. Transuranic isotopes amount to only about 100 Ci.

Isotopic activities in HDT and RPDT waste streams determined to be excessively over- or underestimated were revised. In the case of the one-time-only Naval disposals of 1969, longer-lived contaminants such as Cs-137 were overestimated by several orders of magnitude. In the case of contaminated sludge disposals, net actinide contaminants were underestimated and were not consistent with reported actinide assays of sludge from storage basins at CPP-603. For irradiated hardware, previously reported activities for Nb-94, Ni-63, and C-14 were unrealistically large.

The methodology for defining best-estimate activities and associated upper and lower bounds was based on professional judgment and reasonable assumptions. Bounding uncertainty analysis was waste stream-specific and had significant variations. The rationale for not using rigorous statistical methods was highly variable waste disposals that made such methods not feasible or impractical; therefore, definitions of lower bound, best estimate, and upper bound were not generally grounded in standard statistical methods.

3.4 Naval Reactors Facility

Information in this section has been condensed from Giles, Holdren, and Lengyel (2005). Radiological inventory from NRF replaces HDT and RPDT data only for radiological inventory shipped from 1953 through 1999 to the SDA. Giles, Holdren, and Lengyel rely on inventory provided by U.S. Department of Energy Idaho Branch Office (of Pittsburgh Naval Reactors Office) (DOE-IBO) and their contract staff at NRF. Historical disposal inventories were reconstructed in close collaboration with NRF personnel using information about waste-generating processes, including reactor characteristics and operating histories. Refinements and partitioning to individual shipments are addressed in Section 4; nuclide waste stream summaries are in Appendix C.

In the early 1950s, NRF was established for constructing, operating, and testing prototype Naval nuclear propulsion plants. Three prototype power plant facilities were built and operated over a 42-year period: S1W, A1W, and S5G. In addition, the Expended Core Facility (ECF) was designed, built, and used to examine and test nuclear fuel material. Irradiated fuel material from the Shippingport Atomic Power Station—the first commercial power reactor in the United States—was sent to ECF for examination and testing.

3.4.1 Estimated Inventory

Waste inventory data compiled for the HDT time frame of 1953 through 1983 (LMITCO 1995a) were revised to include new information and to develop more detailed waste characterization required for the OU 7-13/14 RI/FS. The primary goal of revising original radiological inventory estimates was to evaluate and characterize more thoroughly the waste disposals related to:

- General plant waste, fuel material, and process wastes from prototype power plants
- Fuel material waste from the Shippingport reactor PWR-1 core

- Miscellaneous ECF waste streams, such as activated metal end pieces, resins, sludge, and fuel material waste generated during operations of the ECF and by hot cell examination of test specimens of Naval fuel material.

The same approach used for the HDT time frame, with minor differences, was applied to develop revised inventory estimates for the RPDT time frame (LMITCO 1995b). Estimates for 1984 through 1997 are based on information supplied by DOE-IBO, while data for 1998 and 1999 are taken from the RPDT Supplement (Little et al. 2001). The RPDT Supplement published estimates for 1994 through 1999; information supplied by NRF replaces these estimates for 1994 through 1997.

3.4.2 Uncertainties

Uncertainties associated with radionuclide activities presented in this report were derived on the basis of waste streams and are reported by Giles, Holdren, and Lengyel (2005) through 1997 and in the RPDT Supplement (Little et al. 2001) for the years 1998 and 1999.

3.5 Materials and Fuels Complex

The following sections condense information from Carboneau and Vail (2004) detailing refinement of radiological inventory from MFC. Carboneau and Vail verify the data and present the methodology by which the data were developed. Refinements and partitioning to individual shipments are addressed in Section 4; nuclide waste stream summaries are in Appendix C.

3.5.1 Waste Stream Assessment

The MFC site was originally established in 1958 as Argonne National Laboratory-West (ANL-W) with the construction of the Transient Reactor Experiment and Test Facility (TREAT). MFC is the primary center in the United States for testing and demonstrating nuclear energy technology and experiments. The mission at MFC emphasizes technologies associated with nuclear fuel, including advanced methods for fuel reprocessing, improving fuel efficiency, and testing fuel performance. In addition, the MFC mission includes technologies for characterizing nuclear material and restoring the environment, and technologies and processes requiring remote handling of nuclear fuel.

Principal contaminants fall into three categories: activation products, fission products, and actinides (including TRU isotopes). Although waste streams originally identified for this period were reasonably complete, high- and low-activity waste were generally combined, and thus the distinction was not clear between high-activity and low-activity waste in many of those records. In addition, dominant contaminant groupings (such as TRU content) were not always clearly identified.

High-activity disposals of irradiated subassemblies from 1977 through 1983 were combined into a single waste stream designated as ANL-MOD-1H. This new waste stream contained only irradiated hardware. The other waste streams–ANL-MOD-2H, ANL-MOD-3H, and ANL-MOD-4H–included irradiated fissile material consisting of driver fuels, experimental test fuels, irradiated flux wires, blanket material, reprocessing waste, and bulk shipments of low or unirradiated uranium. Much of the irradiated fissile material was generated from destructive examination of highly enriched fuel elements. Generally, fuel samples were chemically dissolved and stabilized in an inert material such as vermiculite; these shipments usually had actinide contents weighing less than 200 g.

A major fraction identified as dry active waste (mainly waste from hot cell operations, including such material as concentrated evaporator bottoms disposed of during the 1960s) had significant amounts of MFPs and actinides as byproducts of the EBR-II reprocessing campaign. In the previous waste stream

breakdown, mainly hot cell waste was identified. However, the dry active waste definition is so general that a distinction is not clear between high-volume LLW and more concentrated fission-actinide contaminant disposals. Thus, high-activity waste stream components (e.g., irradiated fuel dissolved in vermiculite or irradiated flux wires) were made distinct from production of LLW general plant radioactive waste. Since disposal and reporting practices varied between 1960 and 1983, two new waste streams containing high-fission product activities along with actinides were redefined as ANL-MOD-3H and ANL-MOD-2H over the periods 1952–1970 and 1971–1983, respectively.

Bulk shipments of actinide waste usually contained unirradiated uranium; e.g., uranium oxide, natural uranium metal, and depleted uranium (DU). Generally, these bulk shipments had actinide weights (usually uranium) exceeding 50 kg and originated from disposals of ceramic waste from Zero Power Reactor 3 and the Zero Power Physics Reactor, blanket waste from EBR-I, and smaller amounts of waste from unidentified sources. Because these shipments were sporadic, this waste stream was combined with two other special purpose waste streams, including disposal of a radium source capsule and an irradiated tritium test capsule (ANL-MOD-4H). The newly-defined "ANL-MOD-4H" waste stream includes elements of bulk shipments previously reported in other waste streams.

All solid, low-activity waste shipments (i.e., having trace only or no actinide contaminants) associated with waste streams ANL-752-1H, ANL-752-2H, ANL-752-3H, ANL-765-1H, ANL-765-2H, ANL-767-1H, ANL-785-1H and ANL-EBRI-1H were reclassified as general plant waste and combined into waste stream ANL-MOD-5H.

3.5.2 Analysis Approach

The general approach to collecting data was to review any available documentation pertinent to SDA disposal operations. This documentation fell into two categories: (1) shipping manifests or electronic databases with information about SDA disposals and (2) documents with process information connected with disposals.

From 1960 through 1970, documentation was usually hard copies of standardized waste disposal Form 110[e]. These forms generally reported waste types sent to the SDA along with net activities per shipment from 1960 through 1970. Most Form 110 data have been input in the WOS electronic database.

For later disposals from 1971 through 1983, the INL RWMIS database provided a more detailed and reliable source of information—available on Excel spreadsheets—for estimating a complete nuclide-specific breakdown of contaminants of potential concern. These spreadsheets are chronologically ordered by year from 1971 through 1983. For each waste shipment, data entries included date and location of disposal, general contents (waste stream identified numerically), and shipping container (identified numerically). These entries also had estimates of net activities. Generally, net activities also included other, more isotope-specific activities. However, fission products reported by shipment were generally limited to activities for such contaminants as Cs-137 and Sr-90, without reporting other contaminants of interest, such as Tc-99 and I-129. Form 110 data usually contained more detailed information about isotopic contents of each waste shipment. Information from Form 110s and RWMIS for 1971–1983 was cross-checked for consistency.

e. U.S. Atomic Energy standard Form 110, "Idaho Operations Office Waste Disposal Request and Authorization" (AEC 1964). In later periods, the shipping form number transitioned from 110 to 135; however, in this report, 110 and 135 are considered equivalent names.

3.5.3 Overview of Methodologies

Table 1 summarizes the methodologies used to analyze each waste stream. Locations of the best-estimate inventories for each waste stream are also identified in this table.

Table 1. Summary of the methods used to analyze each MFC waste stream for the HDT.

MFC Waste-Streams	Primary Waste Types	Analysis Methods
ANL-MOD-1H	Irradiated SA hardware	Approximately 1,800 SAs were identified as being disposed of at the SDA. Estimated inventories of activation products were associated with each SA based on its EBR-II core position and benchmark inventories.
ANL-MOD-2H and ANL-MOD-3H	Fuel-bearing waste, including irradiated and unirradiated dissolved fuel and fuel-contaminated materials	Scaling factors were used, with the estimated mass of heavy metals that were disposed of at the SDA to estimate the inventory of fission products and actinides that should be present in this waste.
ANL-MOD-4H	Low or unirradiated bulk-actinide waste	Principal contaminants consisted of uranium isotopes and a few other actinides, such as Pu-239 and Np-237. Inventories were assessed based on reported shipping data. Except for an estimate of U-234 inventory (based on the quantity of U-235), no other calculations were made to determine fission product or actinide inventories due to the very low irradiation experienced by this waste.
ANL-MOD-5H	General plant waste consisting of small amounts of fission products, actinides, and activation products	Scaling factors, with reported Cs-137 activities, were used to determine the inventory of fission products, actinides, and activation products that are probably present in these waste items.

EBR-II = Experimental Breeder Reactor-II
HDT = Historical Data Task
SA = subassembly

3.5.4 Estimated Inventory

Irradiated subassemblies were shipped from EBR-II to SDA soil vaults from 1977 through 1993.[f] Estimates of activation products recorded in the RWMIS database did not include all required nuclides needed for risk analysis (e.g., Tc-99 or Ni-59). Consequently, supplementary calculations filled known gaps in the inventory of activation-products in the RPDT and RWMIS databases. A series of reactor physics simulations using typical burnup conditions for EBR-II driver fuel rods were used to calculate the

f. After 1993, irradiated hardware was stored in concrete-lined silos at the RWMC.

buildup of activation products. These simulations generated approximate activation-product activity levels for subassembly components sent to RWMC.

The best-estimate comparison with historical inventories is shown in Appendix B and Appendix C.

Disposals of both irradiated and unirradiated actinide waste were identified in shipping records from 1960 through 1988. As previously mentioned, no data were found regarding MFC waste shipments before 1960. Radioactive waste streams identified included dissolved (irradiated and unirradiated) fuel samples and bulk-actinide disposals of both depleted and natural uranium. In general, these waste streams fell into two categories: (1) sporadic shipments generally having significant bulk weights of unirradiated or low-irradiated actinide waste (mainly uranium) and (2) highly irradiated fuel samples or irradiated test specimens with weights that were generally less than 100 g (not including the container weight). However, some shipments contained unirradiated fuel specimens as well.

Because irradiation histories associated with bulk-actinide waste were very low, fission product and TRU isotopes resulting from fission or capture events were considered negligible for waste streams ANL-MOD-4H (1952 through 1983) and ANL-MOD-2R (1984 through 1993). Therefore, for bulk-actinide waste, no fission products or TRU isotopes (beyond those isotopes already reported by the waste generator) were estimated to be in these waste streams. However, in the case of fuel-bearing waste shipments, waste usually consisted of irradiated fuel specimens or similar material (e.g., irradiated flux wires). In this case, calculations were based on scaling factors to predict the inventory of fission products and TRU that probably was present in this heavy metal waste, but generally was not reported. These calculations were applied to waste streams ANL-MOD-3H and ANL-MOD-2H, but not to waste stream ANL-MOD-2R or ANL-MOD-4H.

Similar to calculating fission products present in general plant waste due to Cs-137, actinides are expected to be in waste streams that contain Cs-137 (or those waste streams that contain irradiated heavy metals). That is, Cs-137 is probably present because it is associated with irradiated fuel particles; therefore, fission products, uranium, and actinides should also be present.

The presence of unirradiated actinide contaminants is separately factored into total inventory. In addition, this method may not be directly applicable to contaminants from specialized irradiation experiments having irradiation histories and compositions deviating significantly from standard characteristics of EBR-II driver fuel.

Explicitly identified waste streams with actinide contaminants (amounts reported by weight) from remote shipping records are thought to be irradiated fuel samples. Waste descriptions for RWMIS pit shipments for 1984–1993 were encoded with generic identification numbers. The RWMIS database did not always clearly identify the process that generated these actinide waste streams or associated material states (e.g., DU, natural uranium, and oxide).

Fission product inventories were estimated to be present in the RPDT fuel-bearing waste stream (ANL-MOD-3R) and in the general plant waste stream (ANL-MOD-4R). Fission products were estimated to be present in fuel-bearing waste because of heavy metal mass inventories (usually uranium), and the fact that this waste generally originated from irradiated fuel. Fission products were estimated to be present in general plant waste due to the presence of Cs-137. Inventories of fission products in these two categories were estimated in similar ways. For fuel-bearing waste, inventory of unreported fission products (or activation products) was estimated by multiplying scaling factors (Ci/kg-HM) by the reported heavy metal inventory (kg). For general plant waste, inventory of unreported radionuclides was estimated by multiplying scaling factors based on Cs-137 (Ci/Ci-Cs137) by the estimated Cs-137 activity (Ci) in this waste.

Estimates of many fission products (except Cs-137) were calculated using scaling factor data[g]; that is, an average isotopic profile quantified activities for the RPDT period. A single gamma emitter was selected from which all other radionuclides could be determined. In this report, Cs-137 was chosen as the reference isotope because it can be easily detected and has been consistently reported in many RWMIS shipments. Logged Cs-137 activities constituted a significant fraction of total reported MFP activities. Net Cs-137 gamma activities were then scaled to calculate the activity of other nuclides of interest—such as I-129—that were not explicitly reported.

The scaling method used in this study is based on highly irradiated EBR-II driver fuel. Derived scaling factors are referenced to Cs-137, and are ultimately based on reactor physics calculations of the inventory present in EBR-II driver fuel pins at maximum burnup conditions. Waste associated with experimental fuel assemblies would have been generated during destructive examination procedures.[h] The isotopic profile associated with experimental assemblies or other irradiated fuel capsules may differ from the profile of EBR-II driver fuel. Consequently, some uncertainties are introduced by applying one set of scaling factors to all waste shipments. However, since the vast majority of all fuel material processed (or reprocessed) at MFC facilities was from EBR-II driver fuel assemblies, this assumption is probably reasonable.

Waste streams containing fission products (and actinides) were buried in both pits and soil vaults. Activity totals are summarized in Carboneau and Vail (2004) for selected fission products. These data are also compared with information for the RPDT (LMITCO 1995b).

3.5.5 Uncertainties

Because of the highly variable and shipment-dependent nature of many waste streams, defining individual uncertainty factors by standard statistical uncertainty methods is not feasible. As in the original HDT and RPDT reports (LMITCO 1995a and 1995b), the methodology for defining best-estimate activities and associated upper and lower bounds was not based on a rigorous statistical error propagation model. Instead, approximation methods were based on professional (e.g., engineering) judgment and other reasonable assumptions.

Based on engineering judgment, an uncertainty factor of at least 1.5 should be applied to the estimated activity of all radionuclides. However, in some cases, uncertainty factors might be as high as a factor of 100. In the case of the bulk-actinide waste stream, ANL-MOD-2R, an uncertainty factor of 1.50 was assumed for all radionuclides. That is, for this waste stream, upper-bound activities were estimated by multiplying best-estimate activities by a factor of 1.50; and lower-bound activities were estimated by dividing best-estimate activities by 1.50.

In the case of waste stream activities that were estimated with the aid of scaling factors, individual uncertainty factors were applied to each radionuclide. These factors ranged from 1.1 for U-235 up to a factor of 100 for Cl-36.

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g. A significant fraction of fission products and TRU contaminants disposed of were connected with EBR-II operations and processes for handling irradiated fuel and decontamination. These process waste streams would have included disposals of LLW connected with hot cell operation and decontamination. Other minor waste streams containing fission product contaminants originated from TREAT, the Zero Power Physics Reactor, and other support facilities. Contributions from support facilities were typically not as significant as from EBR-II.

h. Examples of destructive examination include chemical dissolution of irradiated fuel samples or dissection of fuel samples in hot cells.

3.5.6 Conclusions

This report documents the refined inventory of MFC waste disposal shipments consisting of fission products, activation products, and actinide waste sent to the SDA from 1952 through 1993. Generally, documentation for shipments after 1983 was more complete than for earlier shipments. Total activity estimates for activation products, fission products, and actinide contaminants for the HDT and RPDT periods (1960[i] –1993) are summarized in Carboneau and Vail (2004). In addition to best-estimate data, Carboneau and Vail also incorporate lower-bound and upper-bound activities. The information indicates that ~96% of total activity of all radionuclides disposed of at the SDA from MFC is due to Co-60, which came from activated subassembly steel. The next most important contributor to total activity is Cs-137.

3.6 Rocky Flats Plant

This section presents information condensed from four reports previously published—McKinley and McKinney 1978, Miller and Varvel 2005, Varvel 2005, and Blackwood and Hoffman 2004—that address organic and radiological inventories sent from RFP. For information on partitioning, see Section 4 following this section; for tables summarizing nuclides, see Appendix C. Though organic inventory and radiological inventory for RFP have not been partitioned by shipment on WILD at this time, inventory by shipment can be obtained using a computer-generated scenario (see Section 2).

3.6.1 Refinements due to Waste Retrievals from Pits 11 and 12

The following information has been condensed from the final report by McKinley and McKinney (1978) describing the Initial Drum Retrieval Project. Retrieval started in July 1974 and retrieved drums buried between 1968 and 1970. During the project, 20,262 drums were either disposed of or repackaged and stored, resulting in a total waste volume retrieval of 4,397 m^3. The retrieval of drums from Pits 11 and 12 resulted in a decrease in both radionuclide and chemical inventories. Radionuclide inventories for RFP were reduced by approximately 20,984 total curies. Chemical inventories for RFP were reduced by approximately 5,300 Kg for methylene chloride and 2,784,000 Kg for nitrates.

3.6.2 Organic Inventory Calculation Refinements

The following information has been condensed from reports by Miller and Varvel (2005) and Varvel (2005). These reports provide an organic inventory of Series 743 waste drums from RFP, verify the data, and present the methodology by which the data were developed.

Miller and Varvel (2005) indicate that the majority of organic waste reported buried in the SDA was generated at RFP. A large majority of organics in RFP waste streams was derived from organic "setups" known as Series 743 waste (Vigil 1990). It was later coded at INL as Content Code 3 organic waste to distinguish it from different types of waste shipped to INL from RFP Building 774.

Beginning in 1966, Series 743 drums were shipped from RFP to RWMC for disposal. Shipping manifests provide limited information on each waste shipment, and early manifests do not discriminate between types of generic RFP waste. Several previous investigations attempted to estimate the nature and extent of organic contamination from RFP buried at RWMC (Kudera 1987, Vigil 1988, Arrenholz and Knight 1991, EG&G 1992, Kudera and Brown 1996, and Miller and Navratil 1998), but significant disparities continued. In late 1998, however, new sources of information were found that contributed significantly to providing a defensible estimate of carbon tetrachloride and total VOC mass buried in the SDA. The new information included waste disposal sheets from the RFP shipping facility,

i. This period also represents 1952 through 1993, since there are no data from 1952 through 1959.

Organic Waste Treatment Process Logbooks, and detailed timelines and total volumes of batch processing of RFP 903 waste drums (Miller and Navratil 1998). For the first time, this information enabled an accurate count of the number of Series 743 waste drums buried in the SDA, allowed an accurate reconstruction of drum burial locations by pit, and validated the assumption made by Miller and Navratil that all drums of Series 743 waste contained significant organic sludge mass. An evaluation of the weight of each of the 9,691 drums designated as Series 743 waste indicated that no empty drums were present. Of the 9,691 drums originally buried, 1,015 of these drums were later retrieved from Pits 11 and 12, while 8,676 drums remain buried in the SDA.

Calculations indicate that 1.73E+06 lb (7.86E+05 kg) of carbon tetrachloride—with a standard deviation of 3.1E+05 lb (1.4E+05 kg)—were buried in the SDA, resulting in a 95% upper-confidence limit of 2.3E+06 lb (1.0E+06 kg). In addition, calculations indicate that 2.4E+06 lb (1.1E+06 kg) of total VOCs—with a standard deviation of 4.5E+05 lb (2.0E+05 kg)—were buried in the SDA, resulting in a 95% upper-confidence level of 3.1E+06 lb (1.4E+06 kg).

Varvel (2005) supports the finding in Miller and Varvel (2005) and indicates that, for the masses of tetrachloroethylene (also known as perchloroethylene [PCE]); 1,1,1-trichloroethane (TCA); and trichloroethylene (TCE), estimates changed compared to the original estimates reported in the HDT for these two reasons:

- Additional information was found about Series 743 waste and waste reported to have contained CCl_4 (i.e., PCE, TCA, and TCE) (Miller and Varvel 2005)

- The reported masses for PCE, TCA, and TCE in the HDT were based on an inventory report from 1974, which was not representative of waste produced at RFP and buried in the SDA before 1970.

The mass estimates reported by Varvel (2005) are assumed to be more representative of waste produced at RFP and buried in the SDA before 1970.

Based on the abbreviated investigation into methylene chloride disposal, Varvel (2005) concluded that the amount of methylene chloride reported in the HDT is conservatively reasonable and does not need to be reestimated. This conclusion is based on finding no substantive additional information concerning methylene chloride and the fact that methylene chloride was not reported as being disposed of in significant amounts with Series 743 waste (Miller and Varvel 2005).

3.6.3 Radiological Inventory Refinements

The following section has been condensed from a report by Blackwood and Hoffman (2004) that presents the results of a descriptive statistical analysis of the isotopic characteristics of radioactive waste from RFP. Results of the analysis are presented based on waste types. The analyses indicated the need for substantial bias correction in the reported isotopic mass values; Blackwood and Hoffman deemed data to be too unreliable for waste types for which no bias adjustment had been estimated. The estimated bias corrections are valid only for measurements obtained with more recent versions of the passive active neutron assay system coupled with gamma system assay analysis software (in particular, software incorporating shift register calculations).

Blackwood and Hoffman (2004) evaluated assay data for waste from RFP stored in the TSA to validate the inventory of buried waste in the SDA; however, the evaluation is only applicable to waste buried from 1964 to 1970. Waste buried before 1964 would have a different waste loading based on information compiled by Zodtner and Rogers (1964). Becker (see Appendix D) uses the inventory per unit of weight of waste for assayed waste streams (from Blackwood and Hoffman 2004) and the number

of drums from WILD to compute an overall inventory amount. Becker then compares this overall inventory to the inventory developed by the HDT (LMITCO 1995a). Becker (Appendix D) compares Blackwood and Hoffman's results and HDT inventory values by waste stream and by radionuclide for 1964 to 1970. Using Blackwood and Hoffman's data, the Am-241 inventory by waste stream is higher for all waste streams assessed. Becker concludes that the total amount listed in the HDT is roughly 35% low compared to Blackwood and Hoffman's data. Refining the total inventory of Am-241 increases the total to 8.01E+04 curies.

Uranium in the HDT is listed only in non-plutonium waste streams. Depleted uranium and enriched uranium (EU) each have a waste stream. Blackwood and Hoffman's (2004) assay data indicate that some DU is in plutonium-bearing waste streams. This refinement of the data increases U-238 to 9.07E+01 curies. Appendix D contains details of evaluation of TSA assay data. Isotopic values for the shipments replace HDT and RPDT values for the RFP facility. These data are available by individual shipment, waste stream, or isotope. New data, generated by refining the RFP shipment data, represent the Snapshot for the RI/FS. No additional updates or refinements have been identified for the RFP facility.

Becker (Appendix D) recommends adjustments to nuclide values for americium and uranium, based on the research of Blackwood and Hoffman (2004). The value adjustments include increases for americium and uranium; plutonium values remain the same.

3.7 Other Facilities

Records were reviewed relating to U.S. Bureau of Mines' disposals containing chlorine-36. The pertinent waste stream from the HDT is stream number OFF-UBM-1 H, described as "ore processing waste (includes rare earth elements [40, Fe, O, thorium oxide, uranium chlorides, and iron oxides])." The HDT data input forms on pages OFF-1 65 through OFF-1 70 contain information about these disposals. The data input sheets indicate that the source of details regarding these disposals was obtained from RWMIS, the Clements report (1980), with copies of shipping records USSM-61-1, 62-1, 62-2, 63-1, and 63-1a. For details of the inventory, see Appendix E.

4. PARTITIONING OF FACILITY INVENTORY REFINEMENTS TO WASTE SHIPMENTS

Nuclide values were apportioned to individual shipments to identify disposal areas that might pose increased risk to support continuing risk assessment for the SDA. This apportionment to shipments was accomplished for each facility as described below.

4.1 Isotopic Breakdown of Shipments from Test Area North

The methodology for calculating isotopic breakdown of TAN shipments was taken from Studley et al. (2004). Shipments were assigned to waste streams and isotopic models based on the shipment's origin, contents, and other information. Isotopic models gave the activity ratio of individual radioisotopes to total activity of the waste shipment. However, Studley et al. provided results for only a subset of shipments (i.e., those shipments whose activity exceeded 80% of the total activity of shipments in each year). This provided an isotopic breakdown for approximately 180 shipments.

Therefore, it was necessary to extend the breakdown determined by Studley et al. (2004) to all shipments. To achieve this objective, an isotopic model and waste stream were assigned to all shipments reported by Studley et al. The isotopic breakdown for each shipment was then determined by multiplying the shipment's curie value by the activity ratio for each isotope associated with the assigned model. Model isotopic ratios used are shown in Table 13 of Studley et al. WILD contained 1,343 shipments from TAN; if no curie value was reported for the shipment, an isotopic breakdown was not possible.

Isotopic values for the shipments were input in WILD, which updated and replaced HDT and RPDT values for TAN from 1951 through 1993. The data are available by individual shipment, waste stream, or isotope. New data, generated by refining shipment data from TAN and WILD data for 1994-1999 from the RPDT Supplement (Little et al. 2001), are combined to provide data represented in the Snapshot for the RI/FS. No additional updates or refinements have been identified for the TAN facility.

4.2 Isotopic Breakdown of Shipments from Reactor Technology Complex

Individual waste shipments were assigned refined isotope values based on waste stream and data from ORIGEN2 models. These data were input in WILD and replaced HDT and RPDT data for 1951-1993. New data, generated by refining shipment data from RTC and WILD data for 1994–1999 from the RPDT Supplement (Little et al. 2001), are combined to provide data represented in the Snapshot for the RI/FS. No additional updates or refinements have been identified for the RTC facility.

4.3 Isotopic Breakdown of Shipments from Idaho Nuclear Technology and Engineering Center

Vail, Carboneau, and Longhurst (2004) identified total curie amount by year of isotopes by waste stream sent to the SDA. The first step associated each shipment in WILD with a waste stream. Curie amounts were distributed over shipments by multiplying reported isotope value by percentage of total shipment curies for that year and the waste stream represented by each shipment.

However, review of data in WILD indicated that some waste shipments were not included originally by Vail, Carboneau, and Longhurst (2004). In addition, they identified waste in some years that could not be associated with shipments in WILD. The following sections identify additional work required in order to determine isotopic breakdown of shipments from WILD.

Originally, Vail, Carboneau, and Longhurst (2004) separated uranium isotopes in the Naval experiments waste stream (INTEC-MOD- 4H) and accounted for nuclides in waste stream INTEC-MOD-3H. These isotopes were added back into INTEC-MOD-4H to allow apportioning curies to individual waste shipments. The following were determined to be curie values of U-234, U-235, and U-238 for shipments in INTEC-MOD-4H by using Cs-137 values:

	1962	1966	1968	1975
U-234	2.67E-04	1.28E-03	7.54E-04	8.12E-05
U-235	1.84E-06	8.80E-06	5.20E-06	5.60E-07
U-238	9.20E-08	4.40E-07	2.60E-07	2.80E-08

Since these values were originally considered to be part of INTEC-MOD-3H, they were subtracted from the U-234, U-235, and U-238 assigned to INTEC-MOD-3H. Values were then added as new records for INTEC-MOD-4H. In addition, all original INTEC-MOD-3H values of U-234, U-235, and U-238 in 1963 and 1969 resulted from INTEC-MOD-4H shipments. Therefore, all reported values for these isotopes were removed from -3H and added to -4H. Values are as follows:

	1963	1969
U-234	7.00E-02	2.60E-04
U-235	2.40E-03	8.80E-06
U-238	9.20E-08	1.50E-6

Vail, Carboneau, and Longhurst (2004) did not give values for 1957 or 1958 for any waste streams. However, a number of shipments were entered in WILD for these years. Shipment descriptions were not precise (e.g., “mixed fission products”), even though some shipments had a high curie count. These were classified as general plant waste (INTEC-MOD-9H). Total shipment curies are added for these years and, as done originally by Vail, Carboneau and Longhurst, before 1970 were treated as all Cs-137 and multiplied by scaling factors from the report.

No shipments to the Acid Pit (INTEC-MOD-1H) for 1959, 1962, or 1966 were in WILD, although Vail, Carboneau, and Longhurst (2004) reported curie values for these years. To account for these curies, reported isotope values for 1959 were added to those for 1958, and isotope values for 1962 and 1966 were added to those for 1964. Thus, all curies are accounted for, but are distributed over shipments in different years. Because all shipments were sent to the Acid Pit, assigning curies to a shipment in this way does not affect location determination.

Shipments to the Acid Pit identified in WILD did not include shipment curie amounts. Shipment curie amounts were calculated based on the reported gram quantities of enriched, natural, and DU. Reported Acid Pit curie values were then distributed across WILD shipments based on calculated shipment curies.

Additional WILD shipments in 1967 and 1969 were identified that should have been classified INTEC-MOD-8H. Vail, Carboneau, and Longhurst (2004) did not identify waste in these years for this waste stream. To calculate the nuclide values for these shipments, the historical curies were multiplied by a scaling factor generated from original report data.

Vail, Carboneau, and Longhurst (2004) identified disposal of WCF filters from INTEC to the SDA early in the 1970s. However, shipments of WCF filters were not identified in WILD for these years. Further investigation revealed that the filters were not sent directly to the SDA from INTEC during these years, but filter housings were sent to the TAN Hot Shop for change-out of filter media (Swenson 2004; see Appendix F). The filters then were returned to INTEC and placed back in service. Therefore, Vail, Carboneau, and Longhurst included no isotopic breakdown by shipment of values for INTEC-MOD-5H for these years.

Isotopic values for the shipments were input in WILD, which updated and replaced HDT and RPDT values for INTEC for 1951-1993. Data are available by individual shipment, waste stream, or isotope. New data, generated by refining INTEC shipment data and WILD data for 1994-1999 from the RPDT Supplement (Little et al. 2001), are combined to provide data represented in the Snapshot for the RI/FS. No additional updates or refinements have been identified for INTEC.

4.4 Isotopic Breakdown of Shipments from Naval Reactors Facility

Radionuclide source terms in the SDA were distributed to individual waste shipments over time, using total radionuclide inventories provided by DOE-IBO, and sorted by nuclide and waste stream. Radionuclide inventories were subdivided and distributed to provide a disposal history by year. Radionuclide activities were assigned to individual shipments using the following methods:

1. Waste shipments were segregated into chronological order and grouped by year. Then the descriptive information for all NRF shipments in the inventory database and assignment of classifications was reviewed line-by-line, and waste classifications of 1 through 10 were assigned (corresponding to waste stream codes NRF-MOD-1H through NRF-MOD-10H). In the absence of any information suggesting waste classification, the shipment was assigned Classification 10, General Plant Waste.

2. Activities were assigned to disposal forms that did not record radioactivity for the shipment. No information on total activities was available for most shipments in the 1954 to 1956 interval and several shipments (less than 50) in the 1957 to 1983 interval. In these instances, one of two approaches was applied to assign inventories:

    a. A similar shipment was identified by professional judgment and used as a basis for scaling by weight, volume, exposure rate, or other relevant characteristics.

    b. If a similar shipment could not be identified, the shipment was assigned 1 Ci of activity. Less than 10 shipments were arbitrarily assigned 1 Ci.

3. Best-estimate and upper-bound radionuclide activities were assigned to each individual shipment. Two methods were used for this estimation:

    a. Estimates were obtained by multiplying the reported total activity for a given radionuclide in a given waste stream by the ratio of the total curies reported on the shipping form to the total curies reported for all NRF shipments.

b. Three waste streams are associated with the Shippingport fuel material and the Miscellaneous Natural Uranium Fuel Material. For these waste streams, the percentage of uranium in each shipment was calculated and the weight-based percentage was then used to scale the individual uranium isotope activities for each shipment from the totals listed for these waste streams.

Resulting radionuclide activities were summed for each radionuclide and for each year from 1953 to 1983. Summary totals were checked by comparing calculated total activities to total activities (Giles, Holdren, and Lengyel 2005).

4.5 Isotopic Breakdown of Shipments from Materials and Fuels Complex

Carboneau and Vail (2004) provided, by year, the number of curies of isotopes of interest disposed of at the SDA from MFC for each waste stream.

The first step assigned each shipment in WILD to a waste stream. Shipments were assigned to waste streams based on shipment description, reported isotopes, and disposal dates. Curie amounts were then distributed over the shipments by multiplying reported isotope disposal value by percentage of total shipment curies for that year and waste stream represented by each shipment assigned to the waste stream. Thus, if a shipment had no known curies, there were no isotopes associated with that shipment.

Changes have been made to the MFC data as follows. ANL602SR001/21/6180999999999 was changed to ARA602SR001/21/6180999999999 during the WILD validation process. Because this shipment contained approximately 50% of the curies for waste stream ANL-MOD-3H for 1961, waste stream ANL-MOD-3H was recalculated. Isotope breakdown for waste shipments ANL767SR005/18/61800999999999, ANL767SR010/16/618005012, and ANL767SR011/08/6180021 were changed to reflect that recalculation. These data were added to a change table for updating WILD.

ANL626SR005/14/708000000 was changed to ARA626SR005/14/708000000 during the WILD validation process. The effect of this change on total isotope breakdown for waste stream ANL-MOD-5H for 1970 did not warrant recalculation of the waste stream. Total change to the waste stream total was approximately 0.55 curies out of a total of 733.4 curies for 1970.

ANL771SR007/25/831557100 waste stream assignment was changed to ANL-MOD-5H. Isotope breakdown for this shipment was calculated and added to a change table to update WILD. The effect of this change in total isotope breakdown for waste stream ANL-MOD-5H for 1983 did not warrant recalculating the waste stream.

ANL767SR004/03/626280010 was added to MFC base data because the evaluation process caused a change to WILD. This shipment was assigned to waste stream ANL-MOD-5H for 1962. Isotope breakdown was calculated and the data placed in a change table for updating WILD. The effect of this change on total isotope breakdown for waste stream ANL-MOD-5H for 1962 did not warrant recalculating the waste stream.

Correction of an error in Table B-12, Parts 1 and 3, of Carboneau and Vail (2004) for waste streams ANL-MOD-2H and ANL-MOD-2HEXT modified the values for all years and H-3, C-14, Cl-36, Co-60 and Ni-59. Assignment of isotope values to all shipments associated with these waste streams was recalculated, and the resulting values were input in WILD.

Isotopic values for the shipments were input in WILD, which updated and replaced HDT and RPDT values for MFC for 1951-1993. These data are available by individual shipment, waste stream, or isotope. New data, generated by refining MFC shipment data and WILD data for 1994-1999 from the RPDT Supplement (Little et al. 2001), are combined to provide data represented in the Snapshot for the RI/FS. No additional updates or refinements have been identified for the MFC facility.

4.6 Isotopic Breakdown of Shipments from Rocky Flats Plant

Isotope values for RFP are partitioned to individual shipments by applying a computer-generated scenario to HDT data in WILD. These data are not stored in WILD but are saved in an Excel format by the user. HDT isotope values for RFP waste shipments have been refined by accounting for waste removed from the SDA by retrievals from Pits 11 and 12. In addition, values for Am-241 and U-238 have been refined based on Blackwood and Hoffman (2004) and Becker's recommendation in Appendix D.

Blackwood and Hoffman (2004) examined assay data for stored waste in TSA to validate the inventory in buried waste in the SDA. The evaluation is applicable only to waste buried from 1964 to 1970. Waste buried before 1964 would have different waste loading, based on information from Zodtner and Rogers (1964). This evaluation uses inventory per unit weight of waste for assayed waste streams and the number of drums from WILD to compute an overall inventory amount. This overall inventory is compared to the inventory developed in the HDT (LMITCO 1995a). Becker (Appendix D) compares Blackwood and Hoffman's results and HDT inventory values by waste stream and by radionuclide for 1964 to 1970. The Am-241 inventory by waste stream is higher, using Blackwood and Hoffman's data for all waste streams assessed. Becker concludes that the total amount listed in the HDT is roughly 35% low compared to Blackwood and Hoffman's data. Refining the total inventory of Am-241 increases the total to 8.01E+04 curies.

Uranium in the HDT is listed in non-plutonium waste streams. Depleted uranium and EU each have a waste stream. Blackwood and Hoffman's (2004) assay data indicate that some DU is in plutonium-bearing waste streams. This refinement of the data increases U-238 to 9.07E+01 curies. Appendix D contains details of evaluation of TSA assay data. Isotopic values for the shipments replace HDT and RPDT values for the RFP facility. These data are available by individual shipment, waste stream, or isotope. New data, generated by refining the RFP shipment data, represent the Snapshot for the RI/FS. No additional updates or refinements have been identified for the RFP facility.

4.7 Isotopic Breakdown of Shipments from Other Facilities

The HDT and RPDT addressed other facilities and generators of waste, both on and off INL. Facilities on INL were the Auxiliary Reactor Area, Central Facility Area, Power Burst Facility, and Waste Experimental Reduction Facility. Other generators of waste included deactivation, decontamination, and decommissioning activities and several miscellaneous off-INL generators. Data from other INL facilities have not been refined to date. However, data from these facilities are scheduled to be partitioned to the waste shipment level in fiscal year (FY) 2005. Except for data from the U.S. Bureau of Mines, data from off-INL generators have not been refined. These data are also scheduled for partitioning to individual waste shipment in FY 2005. Data from the U.S. Bureau of Mines were refined in Fuhrman (see Appendix E of this report), and the amount of Cl-36 was reduced. Isotope values in the RI/FS Snapshot are the sum of values in Appendix C and the RPDT Supplement (Little et al. 2001).

4.8 Chemical Contaminant Data

Chemical contaminant data in HDT and RPDT are partitioned to individual shipments. Chemical contaminant values for INL waste shipments have not been refined. However, values for RFP VOCs have been refined. Miller and Varvel (2005) and Varvel (2005) refined values for carbon tetrachloride and PCE. Additionally, the value for methylene chloride has been reduced by the amount removed during waste retrievals from Pits 11 and 12 (McKinley and McKinney 1978).

Calculations in Miller and Varvel (2005) and Varvel (2005) indicate that 1.73E+06 lb (7.86E+05 kg) of carbon tetrachloride—with a standard deviation of 3.1E+05 lb (1.4E+05 kg)—were buried in the SDA, resulting in a 95% upper-confidence limit of 2.3E+06 lb (1.0E+06 kg). In addition, calculations indicate that 2.4E+06 lb (1.1E+06 kg) of total VOCs—with a standard deviation of 4.5E+05 lb (2.0E+05 kg)—were buried in the SDA, resulting in a 95% upper-confidence level of 3.1E+06 lb (1.4E+06 kg).

Varvel (2005) indicates that—based on the abbreviated investigation into methylene chloride disposal—the amount of methylene chloride reported in the HDT is conservatively reasonable and does not need to be reestimated. This conclusion is based on finding no substantive additional information concerning methylene chloride and the fact that methylene chloride was not reported as being disposed of in significant amounts with Series 743 waste (Miller and Varvel 2005).

Chemical contaminants for RFP shipments are partitioned into individual shipments by using a computer-generated scenario. These data are not stored in WILD and are provided to a requestor in the format requested. Values for shipments were input in WILD, which updates and replaces HDT and RPDT values for chemical contaminants. The data are available by individual shipment, waste stream, or isotope. New data, generated by refining the chemical contaminant data, are represented in the RI/FS Snapshot. No additional updates or refinements have been identified.

5. DEVELOPMENT OF RI/FS SNAPSHOT

A data set was taken from WILD on November 29, 2004, to serve as the source term inventory for the OU 7-13/14 RI/BRA and FS. This data set is referred to as the RI/FS Snapshot. Figure 4 shows the relationship of sources of information and refinements of that information that led to the RI/FS Snapshot. Tables 2 and 3 contain a summary of the data used in the RI/FS Snapshot.

In the process of partitioning nuclide values to individual shipments for each facility and subtracting the nuclide values of waste retrieved from Pits 11 and 12, further refinements were made to both radiological and chemical constituents. The following information provides additional details used to develop Tables 2 and 3:

- All inventories listed in Tables 2 and 3 represent estimates at the time of disposal, plus or minus one year.
- Inventory estimates are presented by waste stream for each of 20 contaminants of concern and four additional contaminants of interest.
- With one exception, all anticipated adjustments to original inventories at the time of disposal are reflected in these tables. The exception is inventory reductions attributable to the Accelerated Retrieval Project.
- Rocky Flats Plant adjustments shown in the tables include the following:
  - Reductions for retrievals in Pits 11 and 12
  - Corrections based on assay data from Blackwood and Hoffman (2004)
  - Corrections to original VOC inventories based on Miller and Varvel (2005) as modified to apply rounding protocols consistent with other inventory estimates (i.e., rounded to the second decimal place).

The Cl-36 inventory reported in the HDT was revised from 3.14E-01 Ci to 5.00E-06 Ci, based on reevaluation of waste received from the U.S. Bureau of Mines (see Appendix E).

Appendix B records the development of the RI/FS Snapshot. Subsequent modifications to the source term inventory applied to the Snapshot and used in the RI/FS will be documented in the RI/BRA report.

5.1 Test Area North

The HDT and RPDT isotope values were updated based on evaluation by Studley et al. (2004) of waste disposal data from TAN and the use of ORIGEN2 models. Data from Studley et al. were partitioned (see Section 4) to individual shipments for input in WILD. During partitioning, additional TAN waste shipments were identified. Methods used by Studley et al. were applied to these additional shipments and resulted in an increase in isotope values for TAN from the values in Studley et al. Isotope values in the Snapshot for the RI/FS are the sum of values from Appendix C of this report and the RPDT Supplement (Little et al. 2001). These values are shown in Appendix B, Table B-1.

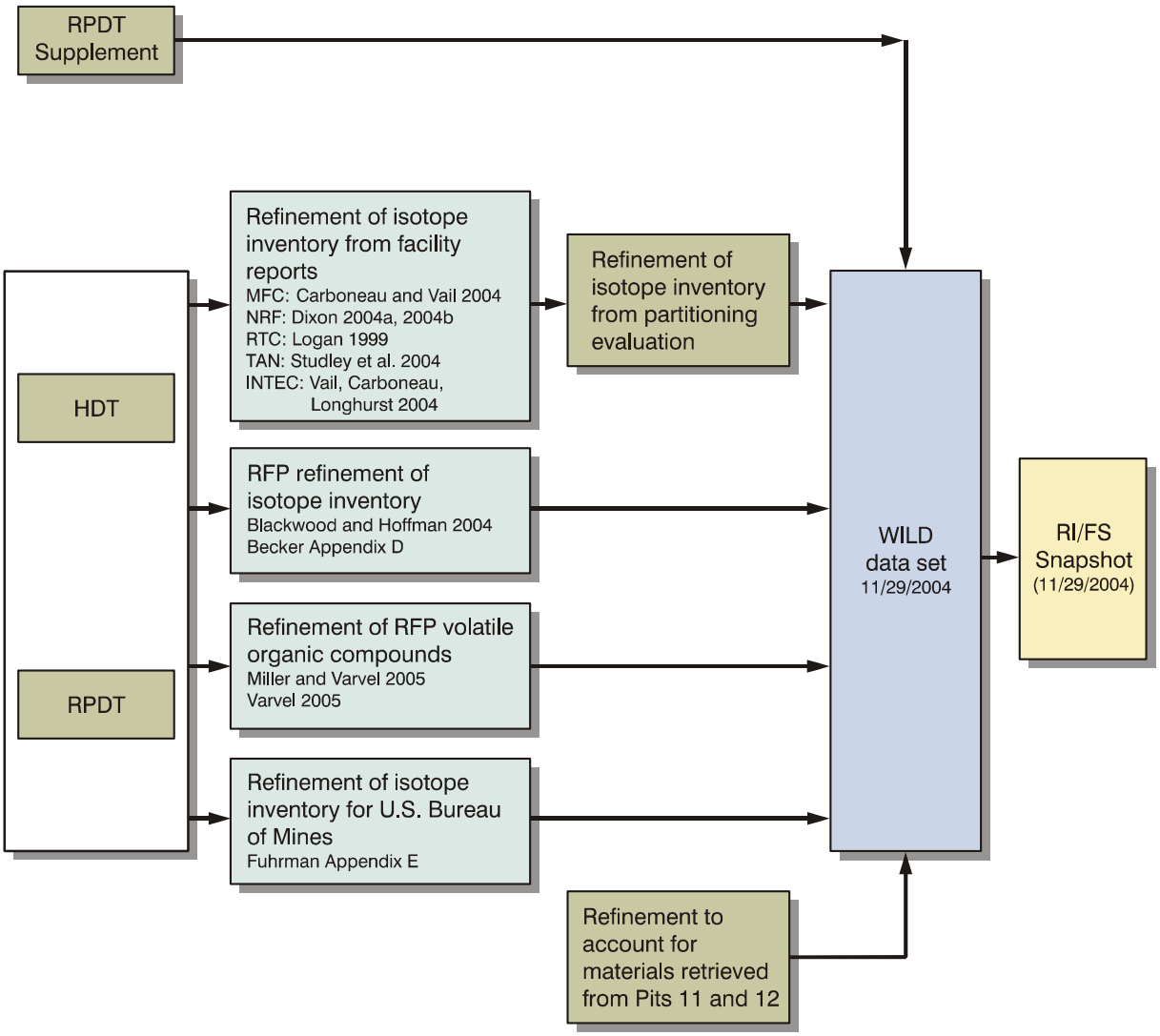

Figure 4. Relationship of sources of information and refinements of that information that led to the RI/FS Snapshot.

Table 2. Best-estimate isotope inventories (curies) for the RI/FS Snapshot.

Radionuclide	MFC	INTEC	NRF	RFP[a]	TAN	RTC	Others	Totals 1952–1999
Am-241	3.05E+00	4.93E+00	1.19E+01	2.30E+05	1.30E+00	2.42E+00	3.31E-01	2.30E+05
C-14	3.86E+01	2.57E+00	7.34E+01	—	1.70E-03	5.31E+02	1.04E+00	6.47E+02
Cl-36	7.98E-03	1.41E-03	2.16E-01	—	1.06E-02	8.83E-01	5.00E-06	1.12E+00
H-3	1.50E+02	3.99E+02	1.99E+02	2.20E-01	1.06E+02	2.66E+06	1.19E+04	2.67E+06
I-129	8.57E-03	2.45E-02	9.21E-03	—	1.26E-03	9.28E-02	2.13E-03	1.38E-01
Nb-94	5.65E+00	5.87E-01	3.17E+01	—	1.32E-02	9.39E+01	2.00E+00	1.34E+02
Np-237	3.43E-02	6.86E-03	4.39E-03	—	2.90E-03	6.88E-02	1.19E-03	1.18E-01
Pu-238	1.15E+01	7.04E+01	1.89E+01	1.85E+03	2.55E+00	1.30E+02	2.16E-01	2.08E+03
Pu-239	5.12E+02	6.19E+00	4.68E+01	6.30E+04	1.45E+01	4.40E+00	5.01E+02	6.41E+04
Pu-240	7.07E+00	9.26E-01	4.07E+01	1.41E+04	3.83E+00	8.22E-01	4.50E+02	1.46E+04
Pu-241	1.23E+02	1.05E+02	3.21E+03	3.77E+05	1.97E+02	1.53E+02	4.84E-01	3.81E+05
Pu-242	1.94E-03	1.85E-03	—	8.48E-01	4.31E-04	5.77E-03	1.46E-05	8.58E-01
Sr-90	2.01E+04	6.31E+04	6.94E+03	—	4.44E+03	3.34E+04	8.22E+03	1.36E+05
Tc-99	1.65E+01	1.10E+01	2.88E+00	—	7.19E-01	8.45E+00	6.43E-01	4.02E+01
U-233	5.69E-04	2.16E-04	4.26E-04	5.40E-01	3.50E-01	6.01E-01	6.05E-01	2.10E+00
U-234	3.37E+00	2.44E+00	8.44E-02	4.07E+01	6.58E+00	8.33E-02	1.02E+01	6.35E+01
U-235	1.49E-01	1.02E+00	1.66E-03	2.15E+00	2.23E-01	5.25E-01	8.13E-01	4.88E+00
U-236	1.08E-01	7.36E-02	1.20E-02	9.83E-01	7.38E-02	1.76E-01	3.67E-03	1.43E+00
U-238	1.39E+00	3.40E-01	8.33E-02	1.29E+02	3.54E+00	4.52E-02	6.69E+00	1.41E+02

a. Estimates have not been adjusted for inventory removed by the Accelerated Retrieval Project.

INTEC Idaho Nuclear Technology and Engineering Center
MFC Materials and Fuels Complex (formerly Argonne National Laboratory-West)
NRF Naval Reactors Facility
RFP Rocky Flats Plant
RTC Reactor Technology Complex (formerly Test Reactor Area)
TAN Test Area North.

Table 3. Best-estimate inventories (grams) of chemicals for the RI/FS Snapshot.

Contaminant	Inventory (g)
Carbon tetrachloride	7.90E+08
Methylene chloride	1.41E+07
Tetrachloroethylene (also known as PCE)	9.87E+07
Nitrates (as nitrogen)	4.56E+08
Chromium	2.32E+06

5.2 Reactor Technology Complex

The HDT and RPDT isotope values were updated based on the WILD evaluation of waste disposal data from RTC and the use of ORIGEN2 models. Refined data from RTC were partitioned (see Appendix A of this report) to individual shipments for input in WILD. Logan's (1999) methods were applied to RTC shipments and resulted in an increase in isotope values for RTC from the values in HDT and RPDT. Isotope values in the RI/FS Snapshot are the sum of values from Appendix C of this report and the RPDT Supplement (Little et al. 2001). These values are shown in Appendix B, Table B-2.

5.3 Idaho Nuclear Technology and Engineering Center

The HDT and RPDT isotope values were updated based on evaluating the waste disposal data by Vail, Carboneau, and Longhurst (2004) and the use of ORIGEN2 models. Data from Vail, Carboneau, and Longhurst were partitioned (see Section 4) to individual shipments for input in WILD. During partitioning, additional waste shipments from INTEC were identified. Methods used by Vail, Carboneau, and Longhurst were applied to these additional shipments and resulted in an increase in isotope values for INTEC from the values shown by Vail, Carboneau, and Longhurst. Isotope values in the RI/FS Snapshot are the sum of values from Appendix C of this report and the RPDT Supplement (Little et al. 2001). These values are shown in Appendix B, Table B-3.

5.4 Naval Reactors Facility

The HDT and RPDT isotope values for NRF were updated by the Naval Reactors: Idaho Branch Office (Dixon 2004a, Dixon 2004b), except for the values for Cm-244, Eu-152, and Eu-154; these values were updated by Little et al. (2001). The RI/FS Snapshot data for NRF are traced to preliminary estimates provided in Dixon (2004a) for waste streams NRF-MOD-1H through NRF-MOD-9H. Dixon (2004b) corrected a typographical error from Dixon (2004a) for Tc-99 in waste streams NRF-MOD-1H and NRF-MOD-2H. The data for NRF-MOD-10H and NRF-MOD-10R are based on analysis by DOE Idaho, Naval Reactors: Idaho Branch Office, and respective contract staff. This analysis received concurrence from Naval Reactors: Idaho Branch Office in Dixon (2004b). Values used in the RI/FS Snapshot are provided in Appendix B, Table B-4. Dixon (2005) provides the final inventory from NRF, and Giles et al. (2005) provides the supplement to NRF's final report. The data provided replaced isotope values identified in the HDT and RPDT.

5.5 Materials and Fuels Complex

Isotope values from the HDT and RPDT were updated based on Carboneau and Vail's (2004) evaluation of disposal data and the use of ORIGEN2 models to develop more comprehensive isotope values. Data from Carboneau and Vail were partitioned (see Section 4) to individual shipments for input in WILD. During partitioning, a typographical error was found in Carboneau and Vail's Summary Table B-12, Sections 1 and 3; correction of this error accounts for the differences between Carboneau and Vail and isotope values in WILD for MFC. Isotope values in the RI/FS Snapshot are the sum of values from Appendix C of this report and the RPDT Supplement (Little et al. 2001). These values are shown in Appendix B, Table B-5.

5.6 Rocky Flats Plant

The HDT and RPDT isotope and chemical values were updated based on retrieval of RFP waste from Pits 11 and 12 (McKinley and McKinney 1978) and Blackwood and Hoffman (2004) data from the TSA assay project for stored TRU waste. The Initial Drum Retrieval Project started retrieval in July 1974 and retrieved drums buried between 1968 and 1970 (McKinley and McKinney 1978). During the project, 20,262 drums were either disposed of or repackaged and stored, resulting in a total waste volume retrieval of 4,397 m^3. The retrieval of drums from Pits 11 and 12 resulted in a decrease in both radionuclide and chemical inventories.

Isotope values in the RI/FS Snapshot are the product of adjustments to Am-241 and U-238 values and subtracting RFP radionuclide values in waste retrieved from Pits 11 and 12 from previous values in the HDT and RPDT. Chemical inventory values in the RI/FS Snapshot are the product of adjustments to methylene chloride and nitrate values from Miller and Varvel (2005) and subtracting RFP chemical contaminants of waste retrieved from Pits 11 and 12 from previous values in the HDT. These values are shown in Appendix B, Tables B-6 and B-7.

5.6.1 Adjustments to Inventory of Radionuclides

Blackwood and Hoffman (2004) examined assay data for stored waste in the TSA to validate buried waste inventory in the SDA. The evaluation is applicable only to waste buried from 1964 to 1970. Waste buried before 1964 would have different waste loading, based on information from Zodtner and Rogers (1964). This evaluation uses inventory per unit weight of waste for assayed waste streams and the number of drums from WILD to compute an overall inventory amount. This overall inventory is compared to the inventory developed in the HDT (LMITCO 1995a). Becker (Appendix D) compares Blackwood and Hoffman's results and the HDT inventory values by waste stream and by radionuclide for 1964 to 1970. Using Blackwood and Hoffman's data, the Am-241 inventory by waste stream is higher for all waste streams assessed. Becker concludes that the total amount listed in the HDT is roughly 35% low compared to Blackwood and Hoffman's data. Refining the total inventory of Am-241 increases the total to 8.01E+04 curies.

Uranium in the HDT is listed only in non-plutonium waste streams. Depleted uranium and EU each have a waste stream. Blackwood and Hoffman's (2004) assay data indicate that some DU is in plutonium-bearing waste streams. This refinement of the data increases U-238 to 9.07E+01 curies. Appendix D contains details of an evaluation of TSA assay data. Isotopic values for the shipments replace HDT and RPDT values for RFP. These data are available by individual shipment, waste stream, or isotope. New data, generated by refining the RFP shipment data, represent the Snapshot for the RI/FS. No additional updates or refinements have been identified for RFP. These values are shown in Appendix B, Table B-6.

5.6.2 Adjustments to Chemical Contaminant Inventory

The HDT values were updated based on the retrieval of drums from Pits 11 and 12 (McKinley and McKinney 1978) and data from Varvel (2005) and Miller and Varvel (2005). Carbon tetrachloride, methylene chloride, PCE, and nitrates are a subset of contaminants listed in the HDT and are reflected in WILD. These values are shown in Appendix B, Table B-7.

5.7 Other Facilities

The HDT and RPDT addressed other facilities and generators of waste, both on and off INL. Facilities on INL were the Auxiliary Reactor Area, Central Facility Area, Power Burst Facility, and Waste Experimental Reduction Facility. Other generators of waste included deactivation, decontamination, and decommissioning activities and several miscellaneous off-INL generators. Data from other INL facilities have not been refined to date. However, data from these facilities are scheduled to be partitioned to the waste shipment level in FY 2005. Except for data from the U.S. Bureau of Mines, isotope data from off-INL generators have not been refined. These data are also scheduled for partitioning to individual waste shipment in FY 2005. Data from the U.S. Bureau of Mines were refined in Fuhrman (see Appendix E of this report), and the amount of Cl-36 was reduced. Isotope values in the RI/FS Snapshot are the sum of values from Appendix C of this report and the RPDT Supplement (Little et al. 2001). These values are shown in Appendix B, Table B-8.

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Appendix A

Reactor Technology Complex Assessment for Nuclides of Concern

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CONTENTS

TABLES

ACRONYMS

ATR	Advanced Test Reactor
CS	carbon steel
EPRI	Electric Power Research Institute
MAP	mixed activation product
MFP	mixed fission product
ORIGEN2	Oak Ridge Isotope GENeration and Depletion Code Version 2
PWR	pressurized water reactor
RTC	Reactor Technology Complex (formerly Test Reactor Area)
TRA	Test Reactor Area (now called Reactor Technology Complex)

Appendix A

Reactor Technology Complex Assessment for Nuclides of Concern

This appendix documents actions taken to assess waste shipments and establishes an inventory for nuclides of concern from the Reactor Technology Complex (RTC; formerly Test Reactor Area). This appendix addresses the assumptions, methodologies, uncertainties, and differences between the inventory generated by this assessment and the Contaminant Inventory Database for Risk Assessment for RTC. This assessment indicates that the carbon-14 reported in the existing inventory is an overestimate. This is attributed to use of scaling factors from the Electric Power Research Institute (EPRI) in the original assessment that do not take into account differences between the physics and reactor materials of RTC and those of commercial power reactors used by EPRI. The new inventory also includes nuclides not reported in the original inventory because they have no EPRI scaling factors. Additionally, this assessment estimated the amount of chlorine contamination in some of the RTC reactor components that generate chlorine-36 when subjected to a neutron flux.

A-1. ASSUMPTIONS

The following are assumptions used in calculations for this report:

- All available waste shipment documents are represented in the data
- All materials disposed of from RTC originated from RTC processes
- Only those shipments classified as core components actually contain core components.

For core components:

- Nuclide breakdown of core component materials are the same as materials evaluated in Logan (1999)
- Core component materials were present in an equal ratio except in the case of identification of a specific core component
- For a shipment classified as core components, the waste mass is used to calculate the nuclide breakdown.

For all other components (not core components):

- The reported curie quantity is used to calculate nuclide breakdown. Some shipment curie quantities were adjusted based on a review of specific shipment.
- If a nuclide was reported, it is assumed that the curie quantity was correctly reported.
- If gross curies were reported with no assignment to a specific nuclide, it is assumed that the quantity was correctly reported.

- If only gross curies were reported, the curies were divided equally between mixed fission products (MFPs) and mixed activation products (MAPs). The division of MFP and MAP were changed in some shipments based on a review of the waste description.

- All reported curies that cannot be accounted for by reported nuclides are assumed to be MFP, MAP, or a combination of both.

- If curies were not reported, it is assumed that no radioactive materials were present in the shipment.

A-2. METHODOLOGY USED

The methodology used to refine the RTC waste shipments is outlined below.

- Waste shipments were evaluated and grouped by similar content (e.g., core components are one group). This grouping is equivalent to a waste stream assignment.

- The waste shipments were assigned (1) waste types and (2) a percentage of the shipment that composed each waste type. These assignments were determined based on the group and shipment description. The waste types for each shipment determined the type of calculations used to quantify the nuclide breakdown for the shipment. The calculations were based either on the waste mass or the reported nuclide curie count of the shipment.

- If the waste shipment was in a group requiring mass calculation, the shipment was evaluated to determine the mass for the calculation. This engineering evaluation of available data determined the mass of waste in the shipment as a percentage of the total shipment mass. The evaluation was recorded in the working database for use in the calculations.

- If the waste shipment was in a group requiring use of reported curies in the calculation, the shipment was evaluated to determine the fraction of curies to be assigned to each waste type (e.g., MFP or MAP).

- For assigning uranium, thorium, or plutonium, the curies of the nuclides—based on the reported values for these nuclides—were entered directly into the database.

- After each shipment was assigned waste types and the data were reviewed to ensure assignments were consistently applied, a query was run that calculated the nuclide breakdown for each waste shipment based on the waste type assignments and isotopic breakdown of each waste type. Results were then grouped by year and waste stream assignment.

- Also applied to this assessment of RTC waste shipments is information developed by Logan (1999), which includes a breakdown of MAP in RTC core materials quantified by an engineering evaluation. This evaluation focused on production of C-14 in core materials, aluminum, hafnium, in-pile tubes, stainless steel, and X-750 (Inconel). The evaluation process:

    - Identified individual core material parts of the Advanced Test Reactor (ATR) at TRA

    - Identified metallurgical content of the major core component

    - Provided a breakdown of MAP as the output of the Oak Ridge Isotope GENeration and Depletion Code Version 2 (ORIGEN2) model from the metallurgical content

- Allowed an estimate of the MAP present in a core component based on the mass of the component and the metal used in construction of the component, since all RTC reactor core materials for the Materials Test Reactor and Engineering Test Reactor are of similar metallurgical breakdown as the ATR

- Provided a means to assign nuclides to an amount of gross curies that has been identified as being from MAP

- Additional modeling identified the nuclide breakdown of MFP for RTC fuel types to support the RTC assignment.

A-3. DATA COLLECTION

Data from WILD and the Radioactive Waste Management Information System were queried for waste shipments from RTC, and these data were placed in a working Access database for evaluation. In addition, ORIGEN2 modeling outputs established new nuclide breakdowns for MAP and MFP (these modeling outputs were based on the materials and fuel makeup of RTC reactor systems).

A-3.1 Pre-Calculational Analysis of Waste Streams

A review of available data indicates that two general methods could be used to calculate the nuclide breakdowns used for the RTC assessments. One method uses the waste mass to calculate the nuclide breakdown. This method is based on work by Logan (1999) and is focused on core components and materials used in RTC reactors. The second method uses the historical reported values as a basis for recalculating the nuclide breakdown, factoring in new data for the breakdown of nuclides from TRA. However, before making calculations, (1) waste streams must be assigned; (2) waste types determined; (3) isotopic breakdowns determined for each waste type; and, in some cases, (4) waste mass must be estimated. The following paragraphs explain these four steps.

The initial step assigns waste shipments to groups (see Table A-1). These groups were not used in the calculation of the isotopic breakdown of each shipment, but were used in the waste stream summation process to be discussed below and for the initial breakdown of the shipments. Shipments in the resin and beryllium groups were not addressed in these calculations.

Table A-1. Shipment group categories.

Beryllium	Core components
Cobalt	MFP
Fuel	NOS
IPT	Resin

IPT = in-pile tube
MFP = mixed fission product
NOS = not otherwise specified

The second step identifies the waste types in the shipments from RTC to the Subsurface Disposal Area (see Table A-2); the groups in the table were used in generating waste types. For example, shipments in the core component and in-pile tube groups were determined to consist of these waste types: aluminum, hafnium, stainless steel, and X-750 (i.e., Inconel). Shipments in the MFP and "not otherwise specified" groups were determined to consist of MFP and MAP. Shipments in the fuel group generally

reported the weight of specific contaminants and were assigned the waste type for the specific contaminant and MFP.

Table A-2. Waste types.

Aluminum	Stainless steel
Cobalt	Th-232
Fuel	U-233
Hafnium	U-234
In-pile tube	U-235
MAP	U-236
MFP	U-238
Pu-239	X-750
Pu-241	

MAP = mixed activation product
MFP = mixed fission product

The third step assigns an isotopic breakdown for each waste type. See Table A-3 for the breakdown figures; the "type" column indicates the calculation for each waste type.

- "Ci/g" indicates the calculation is based on mass.
- "Percent" indicates the calculation is based on reported shipment curies (e.g., 81.639% of the curies in MFP are due to Co-60).
- "Value" indicates that a specific curie amount for the isotope was calculated based on the amount of the isotope reported in the shipment (e.g., the mass of U-235).

Table A-3. Waste types isotopic breakdown.

Waste Type	Isotope	Breakdown	Type
Aluminum	C-14	2.2729E-06	Ci/g
Aluminum	Co-60	0.0079602	Ci/g
Aluminum	Nb-94	2.4422E-07	Ci/g
Aluminum	Ni-59	2.9697E-06	Ci/g
Aluminum	Ni-63	0.0010112	Ci/g
Aluminum	Sr-90	1.0274E-10	Ci/g
Aluminum	Tc-99	7.5493E-11	Ci/g
Cobalt	Co-60	1	percent
Hafnium	C-14	6.14E-06	Ci/g
Hafnium	Co-60	0.003076	Ci/g

Table A-3. (continued).

Waste Type	Isotope	Breakdown	Type
Hafnium	Nb-94	7.181E-07	Ci/g
Hafnium	Ni-59	4.603E-08	Ci/g
Hafnium	Ni-63	1.921E-05	Ci/g
Hafnium	Sr-90	5.409E-06	Ci/g
Hafnium	Tc-99	1.65E-09	Ci/g
In-pile tube	Be-10	3.46417E-10	Ci/g
In-pile tube	C-14	2.9601E-04	Ci/g
In-pile tube	Cl-36	1.19545E-13	Ci/g
In-pile tube	Co-60	0.39965	Ci/g
In-pile tube	Nb-94	6.5002E-05	Ci/g
In-pile tube	Ni-59	2.4301E-04	Ci/g
In-pile tube	Ni-63	0.057955	Ci/g
In-pile tube	Sr-90	1.2579E-06	Ci/g
In-pile tube	Tc-99	3.3766E-08	Ci/g
MAP	Be-10	6.5252E-10	percent
MAP	C-14	4.9434E-04	percent
MAP	Cl-36	2.508E-12	percent
MAP	Co-60	0.81639	percent
MAP	Nb-94	1.2005E-04	percent
MAP	Ni-59	0.000886	percent
MAP	Ni-63	0.1812	percent
MAP	Sr-90	1.0558E-05	percent
MAP	Tc-99	5.9911E-08	percent
MFP	Am-241	1.610157E-06	percent
MFP	Am-243	4.480176E-09	percent
MFP	C-14	1.859724E-10	percent
MFP	Ce-144	0.3137626	percent
MFP	Cm-243	1.499807E-09	percent
MFP	Cm-244	1.317292E-07	percent
MFP	Cs-134	4.827464E-02	percent
MFP	Cs-137	0.1551524	percent
MFP	Eu-152	5.019901E-06	percent
MFP	Eu-154	4.547829E-03	percent

Table A-3. (continued).

Waste Type	Isotope	Breakdown	Type
MFP	H-3	6.09334E-04	percent
MFP	I-129	3.689379E-08	percent
MFP	Np-237	3.039904E-07	percent
MFP	Other	0.103395	percent
MFP	Pm-147	0.2241591	percent
MFP	Pu-238	5.773112E-04	percent
MFP	Pu-239	3.154164E-06	percent
MFP	Pu-240	2.558812E-06	percent
MFP	Pu-241	3.01585E-04	percent
MFP	Pu-242	1.399378E-09	percent
MFP	Ra-226	3.75553E-16	percent
MFP	Ra-228	1.934895E-17	percent
MFP	Sr-90	0.1491838	percent
MFP	Tc-99	2.244598E-05	percent
MFP	Th-228	8.175569E-10	percent
MFP	Th-229	6.816482E-15	percent
MFP	Th-230	5.568648E-13	percent
MFP	Th-232	1.269333E-16	percent
MFP	U-232	1.655259E-09	percent
MFP	U-233	2.27617E-11	percent
MFP	U-234	2.16642E-08	percent
MFP	U-235	2.062685E-07	percent
MFP	U-236	7.840308E-07	percent
MFP	U-238	3.741999E-09	percent
Pu-239	Pu-239	1	value
Pu-241	Pu-241	1	value
Stainless steel	Be-10	5.97943E-11	Ci/g
Stainless steel	C-14	8.0081E-06	Ci/g
Stainless steel	Cl-36	1.45775E-12	Ci/g
Stainless steel	Co-60	0.068983	Ci/g
Stainless steel	Nb-94	7.1229E-08	Ci/g
Stainless steel	Ni-59	4.0243E-05	Ci/g
Stainless steel	Ni-63	0.0059241	Ci/g

Table A-3. (continued).

Waste Type	Isotope	Breakdown	Type
Stainless steel	Sr-90	2.1694E-08	Ci/g
Stainless steel	Tc-99	1.86E-09	Ci/g
Th-232	Th-232	1	value
U-233	U-233	1	value
U-234	U-234	1	value
U-235	U-235	1	value
U-236	U-236	1	value
U-238	U-238	1	value
X-750	Be-10	7.15482E-12	Ci/g
X-750	C-14	7.31821E-07	Ci/g
X-750	Cl-36	1.96031E-14	Ci/g
X-750	Co-60	0.037513	Ci/g
X-750	Nb-94	1.00161E-05	Ci/g
X-750	Ni-59	2.7666E-04	Ci/g
X-750	Ni-63	0.05045	Ci/g
X-750	Sr-90	7.69754E-14	Ci/g
X-750	Tc-99	6.02203E-10	Ci/g

MAP = mixed activation products
MFP = mixed fission products

The fourth and final step determines the percentage of each shipment for each waste type. For waste type "Ci/g," it was necessary to differentiate between the weight of the container and the weight of the waste. In some cases, the shipment document reported the weight of the waste and, in other cases, reported the weight of the waste and the weight of the shipping container. The waste mass was then broken down into the mass of each waste type. For example, shipment TRA542SR009/01/643235 was "A shielded cask weighing 17.5 tons containing scrap metal from canal and reactor." In this case, the reported shipment weight of 700 lbs was actual waste weight and did not include the weight of the shipping container. Table A-4 is the breakdown of the waste in this shipment into its component waste types.

Table A-4. Example of waste type breakdown.

Doc ID	Waste Type	Fraction
TRA542SR009/01/643235	Al	0.79
TRA542SR009/01/643235	Hf	0.15
TRA542SR009/01/643235	Stainless steel	0.04
TRA542SR009/01/643235	X-750	0.02

Al = aluminum
Hf = hafnium

A-3.2 Calculations

For waste type "Ci/g," the curies from each isotope are calculated as the weight of the particular waste type in the shipment times the number of curies per gram of waste type for the isotope, as shown in Equation (A-1) below:

[Shipment Weight]*[Waste Percent]*[Waste Type Fraction]*[Isotope Curies/Gram] (A-1)

For waste type "percent," it was necessary to determine the percentage of reported shipment curies that could be assigned to MFP, MAP, or both. For unspecified contents such as "routine waste" or "boxes of cloth, paper, and rags," shipment curies were split equally between MAP and MFP. For waste type "value," a specific curie amount was determined based usually on the reported mass of the contaminant. Therefore, when the "type" column in Table A-4 is "percent," the curies for each isotope are calculated as the percentage of the total reported curies, as shown in Equation (A-2) below:

[Shipment Curies]*[Waste Type Fraction]*[Isotope percentage] (A-2)

When the "type" column in Table A-4 is "value," the waste type is a single contaminant only. In this case, the number of curies is used resulting from the reported mass of that contaminant or the reported curies quantity. If only the mass of the nuclide was reported, the mass was converted to curies using the specific activity. This was calculated externally to the data system and the value entered directly into the database.

Note that there are no assumptions required as to what waste types can be assigned to what shipment. It would be possible to assign any combination of waste types to a shipment. Summing across the isotopic breakdown for all waste types associated with each shipment produces the number of curies of each isotope for each shipment. In order to determine the number of curies of each isotope for waste streams from TRA, it is only necessary to assign each shipment to a waste stream and sum the curies for each isotope across all shipments assigned to the waste stream. Table A-5 shows the waste streams to which shipments were assigned.

The assumption that a shipment could be assigned to a single waste stream, however, may not be completely valid in all cases. It is possible that isotope curies were assigned to a waste stream based on waste type and group rather than to the waste stream associated with the shipment. The following modifications were made to the waste stream shipment assignment.

- If the group name is "core components" and the waste type is MFP, assign the curies due to MFP to waste stream TRA-603-28.
- If the group name is "core components" and the waste type is U-235, Th-232, or Pu-24, assign to waste stream TRA-603-9.
- If the group name is "fuel" and the waste type is cobalt, assign to waste stream TRA-603-8.

A-4. SHIPMENTS ASSIGNED TO WASTE STREAMS

Waste shipments were assigned to waste streams based on the waste description; this generally followed existing waste stream definitions for TRA. However, some of the definitions were combined to reduce the existing 61 defined waste streams to 14 waste streams. Additionally, the existing differentiation between disposal dates before or after 1983 (indicated by an alpha designator at the end of the waste stream code) was dropped in this process.

Table A-5. RTC waste streams.

OLD WS ID	WS Description	NEW WS ID	NEW WS Description
TRA-603-1	Resins	TRA-603-1N	Resins
TRA-603-1H	Resins	TRA-603-1N	Resins
TRA-603-1R	Resins	TRA-603-1N	Resins
TRA-632-2	Remote handled hot cell waste	TRA-632-2N	Hot cell waste
TRA-632-2R	Hot cell waste consists of small amounts of metal, glassware, plastic bottles, etc.	TRA-632-2N	Hot cell waste
TRA-603-3H	Irradiated end boxes	TRA-603-4N	Core components
TRA-603-4	Core and loop components (from 1994 change-out)	TRA-603-4N	Core components
TRA-603-4H	Core and loop components	TRA-603-4N	Core components
TRA-603-4R	Core and loop components	TRA-603-4N	Core components
TRA-632-1H	Core structural pieces	TRA-603-4N	Core components
TRA-603-6	RTC 645 cold well sludge	TRA-603-6N	Sludge
TRA-603-6H	Sludge	TRA-603-6N	Sludge
TRA-603-6R	Sludge	TRA-603-6N	Sludge
TRA-603-8H	Radioactive sources	TRA-603-8N	Radioactive sources/Co-60 Materials
TRA-603-5H	Uranium in metal	TRA-603-9N	Fuel materials
TRA-603-9H	Irradiated fuel	TRA-603-9N	Fuel materials
TRA-604-1H	Uranium powder	TRA-603-9N	Fuel materials
TRA-614-1H	Capsules of graphite, nickel, and scrap U-235	TRA-603-9N	Fuel materials
TRA-642-5H	Irradiated fuel rods	TRA-603-9N	Fuel materials

Table A-5. (continued).

OLD WS ID	WS Description	NEW WS ID	NEW WS Description
TRA-603-11H	Meat contaminated with botulinus	TRA-603-11N	Meat contaminated with botulinus
TRA-603-13H	Filters	TRA-603-13N	Filters
TRA-603-14H	Continuous air monitors	TRA-603-15N	Metal non-core components
TRA-603-15H	Metal (aluminum, stainless steel, zircaloy, beryllium and cadmium)	TRA-603-15N	Metal non-core components
TRA-603-15R	Metal: aluminum and stainless steel	TRA-603-15N	Metal non-core components
TRA-642-6H	Scrap metal pieces	TRA-603-15N	Metal non-core components
TRA-603-24H	Gas bottles	TRA-603-15N	Metal non-core components
TRA-670-2H	Stainless steel and aluminum	TRA-603-15N	Metal non-core components
TRA-706-1H	Tank	TRA-603-15N	Metal non-core components
TRA-614-2H	Continuous air tank	TRA-603-15N	Metal non-core components
TRA-603-25H	Sodium	TRA-603-15N	Metal non-core components NOTE: *Material combined with a metal shipment.*
TRA-603-35	NPR irradiated target material	TRA-603-15N	Metal non-core components
TRA-603-17H	Dirt	TRA-603-21N	Contaminated bulk materials: concrete, brick, sand, dirt, wood, asphalt
TRA-603-19H	Concrete, metals and wood	TRA-603-21N	Contaminated bulk materials: concrete, brick, sand, dirt, wood, asphalt
TRA-603-20H	Wood	TRA-603-21N	Contaminated bulk materials: concrete, brick, sand, dirt, wood, asphalt
TRA-603-21H	Construction materials, concrete, brick, sand, soil, and asphalt	TRA-603-21N	Contaminated bulk materials: concrete, brick, sand, dirt, wood, asphalt

Table A-5. (continued).

OLD WS ID	WS Description	NEW WS ID	NEW WS Description
TRA-603-21R	Construction materials, concrete, brick, sand, soil, and asphalt	TRA-603-21N	Contaminated bulk materials: concrete, brick, sand, dirt, wood, asphalt
TRA-632-3	Portland cemented waste (treatability study monoliths)	TRA-603-21N	Contaminated bulk materials: concrete, brick, sand, dirt, wood, asphalt
TRA-603-26H	Lead	TRA-603-26N	Lead
TRA-603-26R	Lead	TRA-603-26N	Lead
TRA-603-7H	Glass	TRA-603-27N	Non-compactable waste (i.e., metals, wood, and glass).
TRA-603-7R	Glass	TRA-603-27N	Non-compactable waste (i.e., metals, wood, and glass).
TRA-603-27	Non-compactable waste (i.e., metals, wood, and glass)	TRA-603-27N	Non-compactable waste (i.e., metals, wood, and glass).
TRA-603-27R	Non-compactable waste, glass, metals	TRA-603-27N	Non-compactable waste (i.e., metals, wood, and glass).
TRA-603-10H	Asbestos	TRA-603-28N	Misc. contaminated materials
TRA-603-12H	Vermiculite	TRA-603-28N	Misc. contaminated materials
TRA-603-16H	Paper	TRA-603-28N	Misc. contaminated materials
TRA-603-18H	Rags, floor sweepings, and glassware	TRA-603-28N	Misc. contaminated materials
TRA-603-18R	Rags, floor sweepings, and glassware	TRA-603-28N	Misc. contaminated materials
TRA-603-22H	Rags, floor sweepings, and glassware	TRA-603-28N	Misc. contaminated materials
TRA-603-28R	Combination of glass, halogenated plastic, absorbed liquid, metal chips, wire, etc.	TRA-603-28N	Misc. contaminated materials
TRA-642-4H	Rags, paper and wipes	TRA-603-28N	Misc. contaminated materials
TRA-642-7H	Various combustible materials	TRA-603-28N	Misc. contaminated materials

Table A-5. (continued).

OLD WS ID	WS Description	NEW WS ID	NEW WS Description
TRA-642-7R	Combustible material, such as paper, wood, plastic, rags and wipes	TRA-603-28N	Misc. contaminated materials
TRA-642-2H	Insulation	TRA-603-28N	Misc. contaminated materials
TRA-653-1H	Benzene	TRA-603-28N	Misc. contaminated materials
TRA-603-23H	Terphenyl (Santo-wax)	TRA-603-28N	Misc. contaminated materials
TRA-632-3R	Absorbed liquids	TRA-603-28N	Misc. contaminated materials
TRA-642-3H	HF solidified and neutralized as NaF	TRA-603-28N	Misc. contaminated materials
TRA-642-1H	Fission chambers with foils	TRA-642-1N	Fission chambers with foils
TRA-670-1H	Beryllium reflectors from MTR, ETR, and ATR	TRA-670-1N	Beryllium waste
TRA-670-1R	Beryllium reflectors from ATR	TRA-670-1N	Beryllium waste

ATR = Advanced Test Reactor
ETR = Engineering Test Reactor
HF = hydrofluoric acid
MTR = Materials Test Reactor
NPR = New Production Reactor

Where the waste shipment description indicated that more than one waste stream could be assigned, a single waste stream was assigned that reflected the majority waste type present. In a small number of shipments, however, the waste types present required that they be accounted for in different waste streams. In these cases, logic statements were added to the database queries that assigned the nuclide value to the appropriate waste stream without the shipment classification being changed. Table A-5 contains the new definitions and a matrix of old waste streams to new.

In assigning shipments to waste streams, each shipment was given a group code. This code groups shipments and provides a means both for sorting shipments into subgroups that were used in the assignments and for filtering specific shipments. These specific shipments were those that contained beryllium or resins. For those shipments containing beryllium, nuclide breakdown was taken from inventory in Mullen (2003). Shipments grouped and coded as beryllium shipments were not additionally assessed. The nuclide breakdown of the beryllium waste stream is listed in Section 9 of this Appendix. Shipments grouped and coded as containing resins were additionally evaluated using information generated by Logan (1999) and new analytical data from resin sampling. Methods used for assessment of resin waste are discussed in this Appendix under Section 6, “Resin Nuclide Assignment.”

A-5. REACTOR TECHNOLOGY COMPLEX WASTE CONTAINER DATA

TRA-603-1 - Resin Waste by Year

1960 - 13 shipments identified.
Containers were cardboard boxes, lead casks, and metal casks. The metal casks (disposal tanks) were most likely a special-built carbon steel (CS) tank used for resin disposals in the 1960s. They were built from 12-in., schedule-20 CS pipe. The wall thickness is .25 in. and the specification called for .050-in. corrosion allowance. They held about 6.5 gal of resin.

1961 - 31 shipments identified.
Containers were: one cardboard box, eighteen 2-gal metal cans, five disposal tanks, one 100-gal CS tank, five 500-gal tanks, and one stainless steel tank, size unknown. The 500-gal tanks were most likely fuel oil tanks, modified to collect used resins. Drawings show 1,000-gal tanks that were modified, and some records refer to 500-gal fuel oil tanks used.

1963 - 11 shipments identified.
Containers were: six 2-gal cans, one 500-gal CS tank, and two of unknown type that contained 1-ft^3 resin.

1964 - 9 shipments identified.
Containers consisted of: one 2-gal can, one 30-gal can, one 225-gal galvanized steel tank, one 500-gal CS tank, an unknown number of "GI" cans, and four shipments with only "basket" listed as the container. Since a basket could not contain resin, it is assumed that the resins were in some other form of container.

1965 - 2 shipments identified.
No container information was listed other than that the shipment container was a "cask." Given the size of the shipment (about 1.5 ft^3), it is assumed that the container was a can or tank.

1966 - 7 shipments identified.
Containers were: one 500-gal tank, two shipments of an unknown number of stainless steel containers, and four shipments with no containers identified other than "basket" or "shipping cask."

1967 - 2 shipments identified.
No information regarding containers was listed other than size: one 45-ft^3 container, and one 1-ft^3 container.

1968 - 3 shipments identified.
Containers were: one 225-gal CS tank, one "resin can," and one shipment that did not provide any container information other than "dumpster." It is assumed that resins were packaged in some form to keep the dumpster, which was saved, from being contaminated. The radiation reading on the disposal documents did not indicate high levels.

1969 - 4 shipments identified.
Containers were: two 225-gal CS tanks, one 124-gal CS tank, and one metal container with no other description.

1970 - 4 shipments identified.
Containers were: three 500-gal CS tanks, one 225-gal CS tank, and one "resin can."

1971 - 15 shipments identified.
Containers were: 11 resin tanks of various sizes made of stainless steel or CS, two cardboard boxes, and two "resin cans."

1977 - 1 shipment identified.
Container was one 65-ft^3 container. No other information available.

For the years 1983–1994 (see below), 1,500- and 1,000-gal resin tanks were modified fuel oil tanks of standard 10-gage CS construction. Other tanks listed below were most likely of similar construction.

1983 - 17 shipments identified.
Seventeen 1,000-gal resin tanks.

1984 - 21 shipments identified.
Twenty-one 1,000-gal resin tanks.

1985 - 15 shipments identified.
Fifteen 1,000-gal resin tanks.

1986 - 16 shipments identified.
Sixteen 1,000-gal resin tanks.

1987 - 12 shipments identified.
Twelve 1,000-gal resin tanks.

1988 - 15 shipments identified.
Fifteen 1,000-gal resin tanks.

1989 - 28 shipments identified.
Twenty-eight resin tanks of various sizes ranging from 800 to 1,500 gal.

1990 - 7 shipments identified.
Seven resin tanks of various sizes ranging from 1,000 to 1,400 gal.

1991 - 10 shipments identified.
Ten resin tanks of various sizes ranging from 1,400 to 1,500 gal.

1992 - 8 shipments identified.
Eight 1,500-gal resin tanks.

1993 - 5 shipments identified.
Four 1,500-gal resin tanks and one 55-gal drum.

1994 - 12 shipments identified.
Twelve tanks of various sizes ranging from 375 to 1,550 gal.

TRA-603-2 - Hot Cell Waste

51 shipments identified.
The waste stream form was typical "hot cell" waste (i.e., scrap materials, paper, and metals).
Containers were metal drums, bulk baskets, and inserts.

TRA-603-4 - Core Components

324 shipments identified.

The waste stream form was core and loop components that had been activated by direct exposure to the RTC reactor core flux, but did not include beryllium reflectors and blocks. Containers were wooden boxes, metal drums of various sizes, cans, and bulk baskets.

TRA-603-6 - Sludge

6 shipments identified.

The waste stream form was radioactive sources or Co-60 materials. Containers were two cardboard boxes and four aluminum.

TRA-603-8 - Radioactive Sources/Co-60 Materials

6 shipments identified.

The waste stream form was cobalt source material. Containers were two cardboard boxes and four aluminum.

TRA-603-9 - Fuel Materials

1960 - 2 shipments identified.

One shipment was in four 30-gal drums and was identified as graphite fire block. The other shipment was in two containers of dissolved fuel. Of these two, one was identified as being solidified and placed in a metal can. The other was in a poly bottle and did not indicate if it was solidified; there is no indication of any container other than the poly bottle.

1961 - 6 shipments identified.

Four shipments contained NaK contaminated fuel: three were listed as U-10.59 in zircaloy double cans, and one was listed as 3% enriched yttrium in a stainless steel double can. Two shipments were identified as “natural” uranium and were contained in wooden boxes; no other information about container form was given.

1962 - 4 shipments identified.

Two were contained in 32-gal drums, one shipment was listed as contained in a plastic bag, and one did not identify a container. The shipment that did not indicate a container was listed as U-235, solidified in calcium sulfate.

1963 - 3 shipments identified.

One was encased in concrete, one was fuel plates in an aluminum drum, and one was aluminum-clad capsules in a wooden box.

1964 - 3 shipments identified.

Two did not identify a container other than plastic bags and were listed as unirradiated aluminum-clad U-Zr fuel plates and possibly unirradiated zircaloy-2 clad Th-232 fuel. One was identified as irradiated fuel, and the container was listed as a basket; no other container was identified.

1966 - 3 shipments identified.
One shipment identified 1/2 of 11 fuel plates (container was listed as an aluminum can with the plates wrapped in plastic). One shipment was Zr clad uranium (fuel pins) in a stainless steel container. One shipment did not list a container and identified the presence of 95 aluminum-clad capsules (most likely Th-232).

1967 - 2 shipments identified.
No containers were listed. One shipment was identified as experiment fuel elements, Zr clad, unirradiated. One shipment was identified as ThO2 sample fuel plates.

1968 - 1 shipment identified.
Container was identified as a 5-gal metal can. The shipment listed Thorium, U-233, and U-235 metal mixed together.

1969 - 2 shipments identified.
One shipment was in 1-gal cans and was listed as stainless steel clad fuel capsules. The other shipment did not list a container and was shown as cored fuel capsules.

1970 - 1 shipment identified.
The shipment was in a metal can and was listed as pieces of two unirradiated fuel plates.

1971 - 9 shipments identified.
Seven shipments were in cardboard boxes and were listed as: four U-Al powder, one UO2 powder, one depleted uranium element, and one normal U in aluminum. One shipment was in a 55-gal drum, and another shipment was listed as a poly bottle containing U-235.

1972 - 7 shipments identified.
The containers were identified as being cardboard boxes that contained fuel material in capsules and powdered fuel material in plastic bags. No other container was listed.

1973 - 5 shipments identified.
Containers were identified as cardboard boxes containing fuel elements, powdered fuel material, scrap fuel plates, and depleted uranium fuel elements. No other containers were listed.

1974 - 5 shipments identified.
Two shipments were in cardboard boxes and listed scrap fuel experiments. Three shipments did not identify any container and listed scrap fuel rods, Th-232 rods, and uranium pellets and powder.

1977 - 3 shipments identified.
No container other than an “insert” was identified, and the shipments listed scrap fuel experiments.

TRA-603-11 - Meat Contaminated with Botulinus

3 shipments identified.
The waste stream form was irradiated food stuffs. The containers were sealed cans.

TRA-603-13 - Filters

6 shipments identified.
The waste stream form was filters used in hot cell or glove box HEPA systems. The containers were 55-gal Department of Transportation drums, wooden boxes, and plastic bags.

TRA-603-15 - Metal Non-Core Components

599 shipments identified.

The waste stream form was metals that were not directly associated with the RTC reactor cores. Containers were wooden boxes, drums, and bulk disposals.

TRA-603-21 - Contaminated Bulk Materials

112 shipments identified.

The waste stream was made up of bulk-contaminated materials consisting of concrete, dirt, brick, and other building materials. Some soil shipments were disposed of in 55-gal drums or wooden boxes. Most waste was disposed of without any container.

TRA-603-26 - Lead

1 shipment identified.

The waste stream form was listed as scrap lead wrapped in plastic and placed in a wooden box.

TRA-603-27 - Non-Compactable Waste (i.e., metals, wood, and glass)

113 shipments identified.

The waste stream was in various forms and was similar to general plant waste. Containers were barrels and wooden boxes.

TRA-603-28 - Miscellaneous Contaminated Materials

1,855 shipments identified.

The waste stream was in various forms and consisted of miscellaneous contaminated materials (e.g., paper, rags, plastics, or glass).

TRA-642-1 - Fission Chambers with Foils

2 shipments identified.

The waste stream form was plutonium on fission foils inside a fission chamber. No container information was listed. It is probable that the fission chamber was disposed of as a unit in a can.

TRA-670-1 - Beryllium Waste

8 shipments identified.

The waste stream form was beryllium reflectors and blocks that had been activated by direct exposure to the RTC reactor core flux. The containers were galvanized steel, metal drums of various sizes, and bulk insert baskets.

A-6. RESIN NUCLIDE ASSIGNMENT

Analytical data suggest radionuclides partition differently in various types of resin. Therefore, resin-specific scaling factors were developed for anion resins, cation resins, and mixed resins using sampling data and the Co-60 generated at the Materials Test Reactor, Engineering Test Reactor, and ATR. This determined the curie count of specific radionuclides in purification resins buried in the Subsurface Disposal Area. In addition, scenarios were developed for maximum, minimum, and mid-range cases using accepted filtering constant values.

Scaling factors were developed using the approach defined in Attachment J of Logan (1999). The scaling factor is defined as the geometric mean of the ratio of each isotope related to Co-60 curies. The geometric mean, or central tendency, was used to minimize the impact of outlying data points. This analysis used 25 cation resin samples, 32 anion resin samples, and 19 mixed resin samples. The samples in this analysis included the 7 cation resin samples, 9 anion resin samples, and 8 mixed resin samples used in Attachment J of Logan. Additional resin sample data were obtained from preliminary data from an ongoing resin assessment at TRA. The specific isotopes reported varied from sample to sample, but scaling factors were developed for all reported isotopes. Because of the small number of samples, ratios were not established for Eu-152, Eu-154, Th-228, U-232, U-233, U-234, and Np-237. Table A-6 indicates the number of sample points available for each isotope of concern.

Table A-6. Number of sample points available for each isotope of concern.

	Cation Resin	Anion Resin	Mixed Resin
H-3	5	10	10
C-14	20	31	15
Co-60	25	32	19
Ni-59	10	16	5
Ni-63	19	31	15
Sr-90	20	24	11
Nb-94	23	28	19
Tc-99	23	28	17
I-129	23	28	19
Cs-137	11	6	14
Eu-152	2	1	2
Eu-154	—	—	3
Th-228	—	2	—
U-232	1	—	—
U-235	2	—	—
U-233, U-234, Np-237	—	—	1
Pu-238, Am-241	12	11	3
Pu-239, Pu-240	8	7	1
Cm-242	10	12	2
Cm-244	5	4	1

Coefficients used to partition Co-60 among the three types of resins were 0.013, 0.939, and 0.048 for anion, cation, and mixed bed resins, respectively, in Attachment J of Logan (1999). The amount of Co-60 generated in the RTC reactors by year was also found in Attachment J of Logan. Scenarios for maximum, mid-range, and minimum cases were generated using filtering constants of 0.20, 0.125, and 0.05, respectively. The curie content for each isotope for a given year was calculated by summing the following over each of the three resin types, as shown in Equation (A-3) below:

(Filtration Constant) * (Partitioning Coefficient) * (Isotope Scaling Factor) * (Co-60 Produced per Year). (A-3)

A-7. BERYLLIUM SHIPMENTS NUCLIDE ASSIGNMENT

Other than correcting an error in Table 7-23 from Mullen (2003), no additional refinement to beryllium data was made. Data taken from the report were partitioned to shipments identified and assigned to the beryllium waste stream TRA-670-1N.

A-8. SUMMARY OF DIFFERENCES

In previous analyses of waste shipments, the breakdown of nuclides was estimated by applying nuclide ratios based on the presence of certain flag nuclides. These estimates were based on nuclide breakdown ratios from analysis of pressurized water reactor (PWR) commercial power reactors which did not take into account the differences between RTC test reactors and a commercial power reactor. These differences include metallurgical makeup of core materials, operating power levels, neutron flux levels, and densities. However, Logan's (1999) assessment of the RTC waste shipments is based on an engineering analysis and ORIGEN2 models that establish nuclide breakdowns unique to the RTC reactors for the MFP and MAP generated by core components. These breakdowns were applied to available information and resulted in curie values for individual waste shipments from TRA. For reactor core components, this allowed a more detailed breakdown of nuclides present in these materials.

Because of these improvements in the methods used to estimate the nuclide breakdown, the estimate made in this refinement is more defensible. This refinement allows the nuclide breakdown to be estimated based on an estimate of the mass of materials disposed of in the waste shipment. Using the waste mass for core components will generate differences in the reported nuclide inventories. Additionally, since the ratios of nuclides in MAP for RTC are different from commercial PWR ratios, a better estimate of the MAP nuclide breakdown can be made where gross curies are the only data available.

Table A-7 displays the differences between typical MAP nuclide ratios for a PWR, as published by EPRI (1987). As can be seen in Table A-7, EPRI ratios are approximately twice as large. ORIGEN2 models for RTC core material also indicate that Pu-239 is not produced as MAP in the RTC core component and that Tc-99 and Nb-94 are present in RTC MAP. These nuclides are not represented in EPRI nuclide ratios.

Table A-7. MAP and EPRI ratios.

MAP Ratio	EPRI	Assessment
C-14/Co-60	1.60E-02	3.3138E-04
Fe-55/Co-60	2.90E+00	1.60E+00
Ni-63/Co-60	4.80E-01	2.0242E-01
Pu-239/Co-60	2.00E-04	N/A
EPRI Table 3.1-4 March 1987		

EPRI = Electric Power Research Institute
MAP = mixed activation product

ORIGEN2 was used to analyze RTC fuel to develop an MFP nuclide breakdown for RTC waste shipments. A comparison of the nuclide ratios assessed by EPRI and RTC is presented in Table A-8. As shown in Table A-8, in some cases the EPRI ratios are larger than ratios for TRA, and in other cases they are smaller. This is explained by the enrichment or the percentage of U-235 present in the fuels used, average power density, and neutron flux density. In a commercial PWR, the enrichment is between 2–3%, but, for the RTC test reactors, an enrichment of 93% is typical. The power and neutron density for RTC test reactors are typically higher than those of a commercial PWR, which allowed RTC test reactors to simulate long-term exposure for test materials and experiments. This enrichment and these conditions of RTC reactors generated fission products in different ratios than those found in commercial PWRs.

Table A-8. Comparison of assessed nuclide ratios from EPRI and RTC.

Mixed Fission Product Ratio	EPRI	Assessment
Sr-90/Cs-137	4.60E-03	9.62E-01
Tc-99/Ce-137	8.80E-04	1.45E-04
Pu-239/Cs-137	4.00E-04	2.03E-05
I-129/Cs-137	2.60E-03	2.38E-07
Pu-239/Ce-144	7.10E-03	1.01E-05
Pu-238/Pu-239	1.00E+00	1.83E+02
Pu-241/Pu-239	1.10E+02	9.56E+01
Am-241/Pu-239	5.00E-01	5.10E-01
Cm-242/Pu-239	5.10E-01	3.70E-02
Cm-244/Pu-239	4.70E-01	4.18E-02
EPRI Table 3.1-4 March 1987		

EPRI = Electric Power Research Institute
RTC = Reactor Technology Complex (formerly TRA)

A-9. UNCERTAINTY

The uncertainty used to establish the maximum and minimum values for RTC assessment was +/- 30%. These uncertainties were based on analysis documented in Logan (1999). No additional analysis of uncertainties was performed.

A-10. REACTOR TECHNOLOGY COMPLEX NUCLIDE WASTE STREAM DATA

Table A-9 below presents the RTC waste stream radio nuclide breakdown by year of disposal. (Data were taken from WILD in February 2005.)

Table A-9. RTC waste stream curie values by year.

Waste Stream TRA-670-1N					
Isotope	1970	1976	1977	1987	1993
Ac-227	3.60E-08	4.24E-08	1.79E-08	4.07E-08	5.68E-08
Am-241	1.01E-02	6.49E-02	1.57E-01	5.74E-02	6.31E-02
Am-243	1.35E-02	4.73E-03	1.60E-01	8.18E-03	8.70E-03
Be-10	2.73E+00	9.73E-01	4.37E+00	2.01E+00	1.50E+00
C-14	2.17E+01	7.81E+00	3.51E+01	1.59E+01	1.20E+01
Cl-36	2.29E-01	6.56E-02	3.95E-01	9.66E-02	9.58E-02
Cm-243	3.26E-03	1.99E-03	1.77E-03	9.02E-04	1.54E-03
Cm-244	2.04E+01	1.18E+00	1.28E+00	4.41E+00	4.91E+00
Cm-245	1.81E-03	6.31E-05	7.40E-03	2.59E-04	3.42E-04
Cm-246	9.00E-03	6.00E-05	5.57E-03	9.96E-04	9.54E-04
Cm-247	1.15E-07	2.06E-10	1.20E-04	6.19E-09	6.68E-09
Cm-248	2.86E-06	1.07E-09	2.02E-05	1.13E-07	9.79E-08
Co-60	1.99E+03	7.75E+02	2.00E+03	4.15E+02	5.41E+02
Cs-137	3.00E+01	8.14E+00	1.09E+01	1.03E+01	1.11E+01
Eu-152	1.39E-03	2.54E-01	3.37E-01	2.98E-03	4.05E-03
Eu-154	5.15E+00	1.52E+01	3.06E+01	3.60E+00	4.66E+00
H-3	1.21E+06	1.31E+05	1.05E+06	8.62E+04	1.82E+05
I-129	2.50E-05	7.44E-06	9.73E-02	1.09E-05	1.09E-05
Nb-94	4.82E-02	1.76E-02	9.05E-02	2.80E-02	2.47E-02
Ni-59	2.34E-01	1.65E-01	6.76E-01	1.94E-01	1.75E-01
Ni-63	6.50E+01	2.93E+01	1.21E+02	4.58E+01	3.80E+01
Np-237	1.63E-06	1.57E-06	1.17E-02	1.05E-06	1.32E-06
Pa-231	3.98E-07	2.35E-07	3.08E-05	1.16E-07	2.00E-07
Pb-210	6.27E-10	1.74E-11	1.90E-11	3.49E-11	6.22E-11
Pu-238	8.58E-02	8.38E-02	9.72E-02	4.28E-02	7.12E-02
Pu-239	1.50E-02	2.01E-02	1.24E+00	9.67E-03	1.26E-02
Pu-240	2.09E-02	3.32E-02	5.24E-01	2.47E-02	2.52E-02
Pu-241	7.54E+00	7.21E+00	6.78E+00	2.50E+00	3.97E+00
Pu-242	8.64E-04	4.94E-04	6.64E-01	5.93E-04	6.07E-04
Pu-244	5.14E-09	3.23E-10	9.69E-05	1.74E-09	1.39E-09
Ra-226	1.11E-11	5.70E-12	9.51E-11	1.53E-11	1.50E-11
Ra-228	1.53E-08	1.71E-08	8.07E-09	1.63E-08	1.55E-08
Sr-90	8.43E+00	2.52E+00	2.15E+00	3.00E+00	3.24E+00
Tc-99	2.47E-03	1.01E-03	2.93E-01	1.35E-03	1.36E-03
Th-228	2.39E-04	6.64E-05	2.34E-05	6.90E-05	1.18E-04
Th-229	5.64E-08	3.98E-08	1.75E-06	5.33E-08	5.06E-08

Table A-9. (continued).

Waste Stream TRA-670-1N					
Isotope	1970	1976	1977	1987	1993
Th-230	5.44E-09	2.39E-09	9.28E-07	3.18E-09	3.64E-09
Th-232	2.06E-08	2.83E-08	7.49E-01	1.87E-08	1.91E-08
U-232	4.07E-04	7.53E-05	9.29E-05	6.80E-05	1.19E-04
U-233	5.35E-05	6.19E-05	2.19E-02	3.73E-05	4.27E-05
U-234	1.82E-05	1.35E-05	1.29E-02	1.25E-05	1.34E-05
U-235	1.64E-09	3.69E-09	3.85E-03	8.91E-10	1.03E-09
U-236	6.06E-07	1.17E-06	5.05E-02	7.06E-07	7.18E-07
U-238	2.83E-06	5.46E-06	4.28E+01	3.45E-06	3.40E-06

Waste Stream TRA-642-1N				
Isotope	1969	1975	1976	1977
Am-241	2.25E-06	2.11E-12	7.62E-09	3.87E-12
Am-243	6.27E-09	5.87E-15	2.12E-11	1.08E-14
Be-10	9.14E-10	8.54E-16	3.09E-12	1.57E-15
C-14	6.92E-04	6.47E-10	2.34E-06	1.19E-09
Ce-144	4.39E-01	4.11E-07	1.49E-03	7.55E-07
Cl-36	3.51E-12	3.28E-18	1.19E-14	6.03E-18
Cm-243	2.10E-09	1.96E-15	7.10E-12	3.61E-15
Cm-244	1.84E-07	1.72E-13	6.24E-10	3.17E-13
Co-60	1.14E+00	1.07E-06	3.87E-03	1.96E-06
Cs-134	6.76E-02	6.32E-08	2.29E-04	1.16E-07
Cs-137	2.17E-01	2.03E-07	7.35E-04	3.73E-07
Eu-152	7.03E-06	6.57E-12	2.38E-08	1.21E-11
Eu-154	6.37E-03	5.96E-09	2.15E-05	1.09E-08
H-3	8.53E-04	7.98E-10	2.89E-06	1.47E-09
I-129	5.17E-08	4.83E-14	1.75E-10	8.87E-14
Nb-94	1.68E-04	1.57E-10	5.68E-07	2.89E-10
Ni-59	1.24E-03	1.16E-09	4.20E-06	2.13E-09
Ni-63	2.54E-01	2.37E-07	8.58E-04	4.36E-07
Np-237	4.26E-07	3.98E-13	1.44E-09	7.31E-13
Pm-147	3.14E-01	2.94E-07	1.06E-03	5.39E-07
Pu-238	8.08E-04	7.56E-10	2.73E-06	1.39E-09

Table A-9. (continued).

Waste Stream TRA-642-1N				
Isotope	1969	1975	1976	1977
Pu-239	4.42E-06	4.13E-12	1.49E-08	7.59E-12
Pu-240	3.58E-06	3.35E-12	1.21E-08	6.15E-12
Pu-241	4.22E-04	3.95E-10	1.43E-06	7.25E-10
Pu-242	1.96E-09	1.83E-15	6.63E-12	3.37E-15
Ra-226	5.26E-16	4.92E-22	1.78E-18	9.03E-22
Ra-228	2.71E-17	2.53E-23	9.16E-20	4.65E-23
Sr-90	2.09E-01	1.95E-07	7.06E-04	3.59E-07
Tc-99	3.15E-05	2.95E-11	1.07E-07	5.41E-11
Th-228	1.14E-09	1.07E-15	3.87E-12	1.97E-15
Th-229	9.54E-15	8.93E-21	3.23E-17	1.64E-20
Th-230	7.80E-13	7.29E-19	2.64E-15	1.34E-18
Th-232	1.78E-16	1.66E-22	6.01E-19	3.05E-22
TRA-MFP	1.45E-01	1.35E-07	4.90E-04	2.49E-07
U-232	2.32E-09	2.17E-15	7.84E-12	3.98E-15
U-233	3.19E-11	2.98E-17	1.08E-13	5.47E-17
U-234	3.03E-08	2.84E-14	1.03E-10	5.21E-14
U-235	2.89E-07	2.70E-13	9.77E-10	4.96E-13
U-236	1.10E-06	1.03E-12	3.71E-09	1.89E-12
U-238	5.24E-09	4.90E-15	1.77E-11	9.00E-15

TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.

Table A-9. (continued).

Waste Stream TRA-632-2N																	
Isotope	1960	1963	1969	1971	1972	1973	1974	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Am-241	4.03E-06	1.61E-01	5.15E-06	8.05E-09	1.63E-02	3.04E-04	3.86E-05	7.25E-06	2.72E-05	2.42E-05	1.61E-06	5.44E-03	2.16E-03	6.60E-05	2.84E-04	2.66E-04	2.77E-04
Am-243	1.12E-08	4.48E-04	1.43E-08	2.24E-11	4.53E-05	8.45E-07	1.08E-07	2.02E-08	7.56E-08	6.72E-08	4.48E-09	1.51E-05	6.01E-06	1.84E-07	7.91E-07	7.41E-07	7.71E-07
Be-10	1.63E-09	6.53E-05	2.09E-09	3.26E-12	6.59E-06	2.13E-07	3.13E-08	2.94E-09	1.10E-08	9.79E-09	6.53E-10	2.20E-06	8.75E-07	2.68E-08	1.15E-07	1.08E-07	1.12E-07
C-14	1.24E-03	4.94E+01	1.58E-03	2.47E-06	5.00E+00	1.61E-01	2.37E-02	2.22E-03	8.34E-03	7.42E-03	4.94E-04	1.67E+00	6.63E-01	2.03E-02	8.73E-02	8.18E-02	8.50E-02
Ce-144	7.84E-01	3.14E+04	1.00E+00	1.57E-03	3.17E+03	5.92E+01	7.53E+00	1.41E+00	5.29E+00	4.71E+00	3.14E-01	1.06E+03	4.21E+02	1.29E+01	5.54E+01	5.19E+01	5.40E+01
Cl-36	6.27E-12	2.51E-07	8.03E-12	1.25E-14	2.53E-08	8.19E-10	1.20E-10	1.13E-11	4.23E-11	3.76E-11	2.51E-12	8.47E-09	3.36E-09	1.03E-10	4.43E-10	4.15E-10	4.31E-10
Cm-243	3.75E-09	1.50E-04	4.80E-09	7.50E-12	1.52E-05	2.83E-07	3.60E-08	6.75E-09	2.53E-08	2.25E-08	1.50E-09	5.07E-06	2.01E-06	6.15E-08	2.65E-07	2.48E-07	2.58E-07
Cm-244	3.29E-07	1.32E-02	4.22E-07	6.59E-10	1.33E-03	2.48E-05	3.16E-06	5.93E-07	2.22E-06	1.98E-06	1.32E-07	4.45E-04	1.77E-04	5.40E-06	2.33E-05	2.18E-05	2.27E-05
Co-60	2.04E+00	8.16E+04	2.61E+00	4.08E-03	8.25E+03	2.67E+02	3.92E+01	3.67E+00	1.38E+01	1.22E+01	8.16E-01	2.76E+03	1.09E+03	3.35E+01	1.44E+02	1.35E+02	1.40E+02
Cs-134	1.21E-01	4.83E+03	1.54E-01	2.41E-04	4.88E+02	9.10E+00	1.16E+00	2.17E-01	8.15E-01	7.24E-01	4.83E-02	1.63E+02	6.47E+01	1.98E+00	8.52E+00	7.99E+00	8.30E+00
Cs-137	3.88E-01	1.55E+04	4.96E-01	7.76E-04	1.57E+03	2.93E+01	3.72E+00	6.98E-01	2.62E+00	2.33E+00	1.55E-01	5.24E+02	2.08E+02	6.36E+00	2.74E+01	2.57E+01	2.67E+01
Eu-152	1.25E-05	5.02E-01	1.61E-05	2.51E-08	5.07E-02	9.47E-04	1.20E-04	2.26E-05	8.47E-05	7.53E-05	5.02E-06	1.70E-02	6.73E-03	2.06E-04	8.86E-04	8.31E-04	8.63E-04
Eu-154	1.14E-02	4.55E+02	1.46E-02	2.27E-05	4.60E+01	8.58E-01	1.09E-01	2.05E-02	7.67E-02	6.82E-02	4.55E-03	1.54E+01	6.10E+00	1.86E-01	8.03E-01	7.53E-01	7.82E-01
H-3	1.52E-03	6.09E+01	1.95E-03	3.05E-06	6.16E+00	1.15E-01	1.46E-02	2.74E-03	1.03E-02	9.14E-03	6.09E-04	2.06E+00	8.17E-01	2.50E-02	1.08E-01	1.01E-01	1.05E-01
I-129	9.22E-08	3.69E-03	1.18E-07	1.84E-10	3.73E-04	6.96E-06	8.85E-07	1.66E-07	6.23E-07	5.53E-07	3.69E-08	1.25E-04	4.95E-05	1.51E-06	6.51E-06	6.11E-06	6.35E-06
Nb-94	3.00E-04	1.20E+01	3.84E-04	6.00E-07	1.21E+00	3.92E-02	5.76E-03	5.40E-04	2.03E-03	1.80E-03	1.20E-04	4.06E-01	1.61E-01	4.92E-03	2.12E-02	1.99E-02	2.06E-02
Ni-59	2.21E-03	8.86E+01	2.84E-03	4.43E-06	8.95E+00	2.89E-01	4.25E-02	3.99E-03	1.50E-02	1.33E-02	8.86E-04	2.99E+00	1.19E+00	3.63E-02	1.56E-01	1.47E-01	1.52E-01
Ni-63	4.53E-01	1.81E+04	5.80E-01	9.06E-04	1.83E+03	5.92E+01	8.70E+00	8.15E-01	3.06E+00	2.72E+00	1.81E-01	6.12E+02	2.43E+02	7.43E+00	3.20E+01	3.00E+01	3.12E+01
Np-237	7.60E-07	3.04E-02	9.73E-07	1.52E-09	3.07E-03	5.73E-05	7.30E-06	1.37E-06	5.13E-06	4.56E-06	3.04E-07	1.03E-03	4.08E-04	1.25E-05	5.37E-05	5.03E-05	5.23E-05
Pm-147	5.60E-01	2.24E+04	7.17E-01	1.12E-03	2.27E+03	4.23E+01	5.38E+00	1.01E+00	3.78E+00	3.36E+00	2.24E-01	7.57E+02	3.01E+02	9.19E+00	3.96E+01	3.71E+01	3.86E+01
Pu-238	1.44E-03	5.77E+01	1.85E-03	2.89E-06	5.83E+00	1.09E-01	1.39E-02	2.60E-03	9.74E-03	8.66E-03	5.77E-04	1.95E+00	7.74E-01	2.37E-02	1.02E-01	9.55E-02	9.93E-02
Pu-239	7.89E-06	3.15E-01	1.01E-05	1.58E-08	3.19E-02	5.95E-04	7.57E-05	1.42E-05	5.32E-05	4.73E-05	3.15E-06	1.07E-02	4.23E-03	1.29E-04	5.57E-04	5.22E-04	5.43E-04
Pu-240	6.40E-06	2.56E-01	8.19E-06	1.28E-08	2.59E-02	4.82E-04	6.14E-05	1.15E-05	4.32E-05	3.84E-05	2.56E-06	8.64E-03	3.43E-03	1.05E-04	4.52E-04	4.23E-04	4.40E-04
Pu-241	7.54E-04	3.02E+01	9.65E-04	1.51E-06	3.05E+00	5.69E-02	7.24E-03	1.36E-03	5.09E-03	4.52E-03	3.02E-04	1.02E+00	4.04E-01	1.24E-02	5.32E-02	4.99E-02	5.19E-02
Pu-242	3.50E-09	1.40E-04	4.48E-09	7.00E-12	1.41E-05	2.64E-07	3.36E-08	6.30E-09	2.36E-08	2.10E-08	1.40E-09	4.73E-06	1.88E-06	5.74E-08	2.47E-07	2.32E-07	2.41E-07
Ra-226	9.39E-16	3.76E-11	1.20E-15	1.88E-18	3.79E-12	7.08E-14	9.01E-15	1.69E-15	6.34E-15	5.63E-15	3.76E-16	1.27E-12	5.04E-13	1.54E-14	6.63E-14	6.22E-14	6.46E-14
Ra-228	4.84E-17	1.93E-12	6.19E-17	9.67E-20	1.96E-13	3.65E-15	4.64E-16	8.71E-17	3.27E-16	2.90E-16	1.93E-17	6.54E-14	2.59E-14	7.93E-16	3.42E-15	3.20E-15	3.33E-15

Table A-9. (continued).

Waste Stream TRA-632-2N																	
Isotope	1960	1963	1969	1971	1972	1973	1974	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Sr-90	3.73E-01	1.49E+04	4.77E-01	7.46E-04	1.51E+03	2.81E+01	3.58E+00	6.71E-01	2.52E+00	2.24E+00	1.49E-01	5.04E+02	2.00E+02	6.12E+00	2.63E+01	2.47E+01	2.57E+01
Tc-99	5.63E-05	2.25E+00	7.20E-05	1.13E-07	2.27E-01	4.25E-03	5.42E-04	1.01E-04	3.80E-04	3.38E-04	2.25E-05	7.60E-02	3.02E-02	9.23E-04	3.97E-03	3.72E-03	3.87E-03
Th-228	2.04E-09	8.18E-05	2.62E-09	4.09E-12	8.26E-06	1.54E-07	1.96E-08	3.68E-09	1.38E-08	1.23E-08	8.18E-10	2.76E-06	1.10E-06	3.35E-08	1.44E-07	1.35E-07	1.41E-07
Th-229	1.70E-14	6.82E-10	2.18E-14	3.41E-17	6.89E-11	1.29E-12	1.64E-13	3.07E-14	1.15E-13	1.02E-13	6.82E-15	2.30E-11	9.14E-12	2.79E-13	1.20E-12	1.13E-12	1.17E-12
Th-230	1.39E-12	5.57E-08	1.78E-12	2.78E-15	5.63E-09	1.05E-10	1.34E-11	2.51E-12	9.40E-12	8.35E-12	5.57E-13	1.88E-09	7.47E-10	2.28E-11	9.83E-11	9.22E-11	9.58E-11
Th-232	3.17E-16	1.27E-11	4.06E-16	6.35E-19	1.28E-12	2.39E-14	3.05E-15	5.71E-16	2.14E-15	1.90E-15	1.27E-16	4.29E-13	1.70E-13	5.20E-15	2.24E-14	2.10E-14	2.18E-14
TRA-MFP	2.58E-01	1.03E+04	3.31E-01	5.17E-04	1.04E+03	1.95E+01	2.48E+00	4.65E-01	1.74E+00	1.55E+00	1.03E-01	3.49E+02	1.39E+02	4.24E+00	1.82E+01	1.71E+01	1.78E+01
U-232	4.14E-09	1.66E-04	5.30E-09	8.28E-12	1.67E-05	3.12E-07	3.97E-08	7.45E-09	2.79E-08	2.48E-08	1.66E-09	5.59E-06	2.22E-06	6.79E-08	2.92E-07	2.74E-07	2.85E-07
U-233	5.69E-11	2.28E-06	7.28E-11	1.14E-13	2.30E-07	4.29E-09	5.46E-10	1.02E-10	3.84E-10	3.41E-10	2.28E-11	7.69E-08	3.05E-08	9.33E-10	4.02E-09	3.77E-09	3.92E-09
U-234	5.42E-08	2.17E-03	6.93E-08	1.08E-10	2.19E-04	4.08E-06	5.20E-07	9.75E-08	3.66E-07	3.25E-07	2.17E-08	7.32E-05	2.90E-05	8.88E-07	3.82E-06	3.59E-06	3.73E-06
U-235	5.16E-07	2.06E-02	6.60E-07	1.03E-09	2.08E-03	3.89E-05	4.95E-06	9.28E-07	3.48E-06	3.09E-06	2.06E-07	6.97E-04	2.77E-04	8.46E-06	3.64E-05	3.41E-05	3.55E-05
U-236	1.96E-06	7.84E-02	2.51E-06	3.92E-09	7.92E-03	1.48E-04	1.88E-05	3.53E-06	1.32E-05	1.18E-05	7.84E-07	2.65E-03	1.05E-03	3.21E-05	1.38E-04	1.30E-04	1.35E-04
U-238	9.35E-09	3.74E-04	1.20E-08	1.87E-11	3.78E-05	7.06E-07	8.98E-08	1.68E-08	6.31E-08	5.61E-08	3.74E-09	1.26E-05	5.02E-06	1.53E-07	6.60E-07	6.19E-07	6.44E-07
TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.																	

Table A-9. (continued).

Waste Stream TRA-603-9N																					
Isotope	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1980	1981	1987
Am-241	1.57E-08	2.42E-02	1.35E-05	3.62E-02	1.77E-04		4.98E-03	1.10E-03		1.66E-06	1.61E-05	5.25E-09	2.35E-14	8.45E-08	1.15E-13			1.95E-14			
Am-243	4.37E-11	6.72E-05	3.76E-08	1.01E-04	4.93E-07		1.39E-05	3.07E-06		4.61E-09	4.48E-08	1.46E-11	6.54E-17	2.35E-10	3.19E-16			5.42E-17			
Be-10				8.16E-06																	
C-14	1.81E-12	2.79E-06	1.56E-09	6.18E+00	2.05E-08		5.76E-07	1.28E-07		1.91E-10	1.86E-09	6.06E-13	2.71E-18	9.76E-12	1.32E-17			2.25E-18			
Ce-144	3.06E-03	4.71E+03	2.64E+00	7.06E+03	3.45E+01		9.71E+02	2.15E+02		3.23E-01	3.14E+00	1.02E-03	4.58E-09	1.65E-02	2.24E-08			3.80E-09			
Cl-36				3.14E-08																	
Cm-243	1.46E-11	2.25E-05	1.26E-08	3.37E-05	1.65E-07		4.64E-06	1.03E-06		1.54E-09	1.50E-08	4.89E-12	2.19E-17	7.87E-11	1.07E-16			1.81E-17			
Cm-244	1.28E-09	1.98E-03	1.11E-06	2.96E-03	1.45E-05		4.08E-04	9.04E-05		1.35E-07	1.32E-06	4.29E-10	1.92E-15	6.92E-09	9.38E-15			1.59E-15			
Co-60				1.02E+04																	
Cs-134	4.71E-04	7.24E+02	4.06E-01	1.09E+03	5.31E+00		1.49E+02	3.31E+01		4.96E-02	4.83E-01	1.57E-04	7.05E-10	2.53E-03	3.44E-09			5.84E-10			
Cs-137	1.51E-03	2.33E+03	1.30E+00	3.49E+03	1.71E+01		4.80E+02	1.06E+02		1.59E-01	1.55E+00	5.05E-04	2.26E-09	8.15E-03	1.11E-08			1.88E-09			
Eu-152	4.89E-08	7.53E-02	4.22E-05	1.13E-01	5.52E-04		1.55E-02	3.44E-03		5.16E-06	5.02E-05	1.64E-08	7.33E-14	2.64E-07	3.58E-13			6.07E-14			
Eu-154	4.43E-05	6.82E+01	3.82E-02	1.02E+02	5.00E-01		1.41E+01	3.12E+00		4.68E-03	4.55E-02	1.48E-05	6.64E-11	2.39E-04	3.24E-10			5.50E-11			
H-3	5.94E-06	9.14E+00	5.12E-03	1.37E+01	6.70E-02		1.89E+00	4.18E-01		6.26E-04	6.09E-03	1.98E-06	8.89E-12	3.20E-05	4.34E-11			7.37E-12			
I-129	3.60E-10	5.53E-04	3.10E-07	8.30E-04	4.06E-06		1.14E-04	2.53E-05		3.79E-08	3.69E-07	1.20E-10	5.38E-16	1.94E-09	2.63E-15			4.46E-16			
Nb-94				1.50E+00																	
Ni-59				1.11E+01																	
Ni-63				2.26E+03																	
Np-237	2.96E-09	4.56E-03	2.55E-06	6.84E-03	3.34E-05		9.41E-04	2.09E-04		3.13E-07	3.04E-06	9.90E-10	4.44E-15	1.60E-08	2.17E-14			3.68E-15			
Pm-147	2.19E-03	3.36E+03	1.88E+00	5.04E+03	2.47E+01		6.94E+02	1.54E+02		2.30E-01	2.24E+00	7.30E-04	3.27E-09	1.18E-02	1.60E-08			2.71E-09			
Pu-238	5.63E-06	8.66E+00	4.85E-03	1.30E+01	6.35E-02		1.79E+00	3.96E-01		5.93E-04	5.77E-03	1.88E-06	8.43E-12	3.03E-05	4.11E-11			6.99E-12			
Pu-239	3.53E+00	4.73E-02	2.65E-05	7.10E-02	3.47E-04		9.76E-03	2.16E-03		3.24E-06	3.15E-05	1.03E-08	4.60E-14	1.66E-07	2.25E-13			3.82E-14			
Pu-240	2.49E-08	3.84E-02	2.15E-05	5.76E-02	2.81E-04		7.92E-03	1.76E-03		2.63E-06	2.56E-05	8.34E-09	3.73E-14	1.34E-07	1.82E-13			3.10E-14			
Pu-241	2.60E+01	4.52E+00	2.53E-03	6.79E+00	3.32E-02	7.90E-01	9.34E-01	2.07E-01	7.90E-01	3.10E-04	3.02E-03	9.82E-07	4.40E-12	1.58E-05	2.15E-11			3.65E-12			7.90E-01
Pu-242	1.36E-11	2.10E-05	1.18E-08	3.15E-05	1.54E-07		4.33E-06	9.60E-07		1.44E-09	1.40E-08	4.56E-12	2.04E-17	7.35E-11	9.97E-17			1.69E-17			
Ra-226	3.66E-18	5.63E-12	3.15E-15	8.45E-12	4.13E-14		1.16E-12	2.58E-13		3.86E-16	3.76E-15	1.22E-18	5.48E-24	1.97E-17	2.68E-23			4.54E-24			
Ra-228	1.89E-19	2.90E-13	1.63E-16	4.35E-13	2.13E-15		5.99E-14	1.33E-14		1.99E-17	1.93E-16	6.30E-20	2.82E-25	1.02E-18	1.38E-24			2.34E-25			
Sr-90	1.45E-03	2.24E+03	1.25E+00	3.36E+03	1.64E+01		4.62E+02	1.02E+02		1.53E-01	1.49E+00	4.86E-04	2.18E-09	7.83E-03	1.06E-08			1.81E-09			

Table A-9. (continued).

Waste Stream TRA-603-9N																					
Isotope	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1980	1981	1987
Tc-99	2.19E-07	3.37E-01	1.89E-04	5.06E-01	2.47E-03		6.95E-02	1.54E-02		2.31E-05	2.24E-04	7.31E-08	3.28E-13	1.18E-06	1.60E-12			2.72E-13			
Th-228	7.97E-12	1.23E-05	6.87E-09	1.84E-05	8.99E-08		2.53E-06	5.61E-07		8.40E-10	8.17E-09	2.66E-12	1.19E-17	4.29E-11	5.82E-17			9.89E-18			
Th-229	6.65E-17	1.02E-10	5.73E-14	1.53E-10	7.50E-13		2.11E-11	4.68E-12		7.01E-15	6.82E-14	2.22E-17	9.95E-23	3.58E-16	4.86E-22			8.25E-23			
Th-230	5.43E-15	8.35E-09	4.68E-12	1.25E-08	6.13E-11		1.72E-09	3.82E-10		5.72E-13	5.57E-12	1.81E-15	8.13E-21	2.92E-14	3.97E-20			6.74E-21			
Th-232	1.50E-01	1.90E-12	1.53E-05	2.86E-12	1.40E-14	4.50E-01	4.50E-01	1.50E-01	1.32E-03	1.50E-01	1.50E-01	4.50E-01	1.85E-24	6.66E-18	4.74E-05			1.63E-07			1.50E-01
TRA-MFP	1.01E-03	1.55E+03	8.69E-01	2.33E+03	1.14E+01		3.20E+02	7.09E+01		1.06E-01	1.03E+00	3.37E-04	1.51E-09	5.43E-03	7.37E-09			1.25E-09			
U-232	1.61E-11	2.48E-05	1.39E-08	3.72E-05	1.82E-07		5.12E-06	1.14E-06		1.70E-09	1.66E-08	5.39E-12	2.42E-17	8.69E-11	1.18E-16			2.00E-17			
U-233	2.22E-13	3.41E-07	1.91E-10	5.12E-07	2.50E-09		7.05E-08	1.56E-08	6.01E-01	2.34E-11	2.28E-10	7.41E-14	3.32E-19	1.19E-12	1.62E-18			2.75E-19			
U-234	2.11E-10	1.14E-02	1.12E-02	2.91E-03	2.38E-06		2.31E-02	2.89E-02		2.23E-08	2.17E-07	3.73E-04	3.16E-16	1.14E-09	1.54E-15			2.62E-16			
U-235	2.01E-09	3.57E-03	7.45E-04	4.96E-03	3.22E-05	1.00E-03	1.40E-03	1.44E-03	1.32E-04	5.96E-05	1.02E-04	3.39E-04	1.13E-04	1.01E-02	2.16E-04	8.36E+00	7.53E-04	1.05E-03	2.60E-01	2.00E-01	
U-236	7.64E-09	1.18E-02	1.73E-05	1.77E-02	8.62E-05		2.52E-03	6.59E-04		8.06E-07	7.84E-06	1.62E-06	1.14E-14	4.12E-08	5.59E-14			9.49E-15			
U-238	3.65E-11	7.27E-05	1.40E-02	8.49E-05	4.12E-07		1.85E-05	1.13E-05		3.85E-09	3.74E-08	4.07E-04	1.94E-05	3.38E-03	7.67E-04	2.56E-04		7.40E-04	7.05E-06	2.22E-02	

TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.

Table A-9. (continued).

Waste Stream TRA-603-8N				
Isotope	1960	1962	1963	1965
Co-60	2.84E+00	3.00E+03	1.90E+04	1.80E+04

Waste Stream TRA-603-6N											
Isotope	1963	1964	1967	1970	1973	1974	1975	1976	1981	1985	1991
Am-241	8.05E-10	4.03E-07	1.61E-09	2.42E-08	9.66E-09	1.21E-09	2.42E-10	1.09E-09	6.76E-10	8.05E-11	3.38E-10
Am-243	2.24E-12	1.12E-09	4.48E-12	6.72E-11	2.69E-11	3.36E-12	6.72E-13	3.02E-12	1.88E-12	2.24E-13	9.39E-13
Be-10	3.26E-13	1.63E-10	6.53E-13	9.79E-12	3.92E-12	4.89E-13	9.79E-14	4.40E-13	2.74E-13	3.26E-14	1.37E-13
C-14	2.47E-07	1.24E-04	4.94E-07	7.42E-06	2.97E-06	3.71E-07	7.42E-08	3.34E-07	2.08E-07	2.47E-08	1.04E-07
Ce-144	1.57E-04	7.85E-02	3.14E-04	4.71E-03	1.88E-03	2.35E-04	4.71E-05	2.12E-04	1.32E-04	1.57E-05	6.58E-05
Cl-36	1.25E-15	6.28E-13	2.51E-15	3.76E-14	1.50E-14	1.88E-15	3.76E-16	1.69E-15	1.05E-15	1.25E-16	5.26E-16
Cm-243	7.50E-13	3.75E-10	1.50E-12	2.25E-11	9.00E-12	1.12E-12	2.25E-13	1.01E-12	6.30E-13	7.50E-14	3.14E-13
Cm-244	6.59E-11	3.30E-08	1.32E-10	1.98E-09	7.90E-10	9.88E-11	1.98E-11	8.89E-11	5.53E-11	6.59E-12	2.76E-11
Co-60	4.08E-04	2.04E-01	8.16E-04	1.22E-02	4.90E-03	6.12E-04	1.22E-04	5.51E-04	3.43E-04	4.08E-05	1.71E-04
Cs-134	2.41E-05	1.21E-02	4.83E-05	7.24E-04	2.90E-04	3.62E-05	7.24E-06	3.26E-05	2.03E-05	2.41E-06	1.01E-05
Cs-137	7.76E-05	3.88E-02	1.55E-04	2.33E-03	9.31E-04	1.16E-04	2.33E-05	1.05E-04	6.52E-05	7.76E-06	3.25E-05
Eu-152	2.51E-09	1.26E-06	5.02E-09	7.53E-08	3.01E-08	3.76E-09	7.53E-10	3.39E-09	2.11E-09	2.51E-10	1.05E-09
Eu-154	2.27E-06	1.14E-03	4.55E-06	6.82E-05	2.73E-05	3.41E-06	6.82E-07	3.07E-06	1.91E-06	2.27E-07	9.54E-07
H-3	3.05E-07	1.52E-04	6.09E-07	9.14E-06	3.66E-06	4.57E-07	9.14E-08	4.11E-07	2.56E-07	3.05E-08	1.28E-07
I-129	1.84E-11	9.23E-09	3.69E-11	5.53E-10	2.21E-10	2.77E-11	5.53E-12	2.49E-11	1.55E-11	1.84E-12	7.74E-12
Nb-94	6.00E-08	3.00E-05	1.20E-07	1.80E-06	7.20E-07	9.00E-08	1.80E-08	8.10E-08	5.04E-08	6.00E-09	2.52E-08
Ni-59	4.43E-07	2.22E-04	8.86E-07	1.33E-05	5.32E-06	6.64E-07	1.33E-07	5.98E-07	3.72E-07	4.43E-08	1.86E-07
Ni-63	9.06E-05	4.53E-02	1.81E-04	2.72E-03	1.09E-03	1.36E-04	2.72E-05	1.22E-04	7.61E-05	9.06E-06	3.80E-05
Np-237	1.52E-10	7.61E-08	3.04E-10	4.56E-09	1.82E-09	2.28E-10	4.56E-11	2.05E-10	1.28E-10	1.52E-11	6.37E-11
Pm-147	1.12E-04	5.61E-02	2.24E-04	3.36E-03	1.34E-03	1.68E-04	3.36E-05	1.51E-04	9.41E-05	1.12E-05	4.70E-05
Pu-238	2.89E-07	1.44E-04	5.77E-07	8.66E-06	3.46E-06	4.33E-07	8.66E-08	3.90E-07	2.42E-07	2.89E-08	1.21E-07
Pu-239	1.58E-09	7.89E-07	3.15E-09	4.73E-08	1.89E-08	2.37E-09	4.73E-10	2.13E-09	1.32E-09	1.58E-10	6.61E-10
Pu-240	1.28E-09	6.40E-07	2.56E-09	3.84E-08	1.54E-08	1.92E-09	3.84E-10	1.73E-09	1.07E-09	1.28E-10	5.37E-10
Pu-241	1.51E-07	7.55E-05	3.02E-07	4.52E-06	1.81E-06	2.26E-07	4.52E-08	2.04E-07	1.27E-07	1.51E-08	6.32E-08
Pu-242	7.00E-13	3.50E-10	1.40E-12	2.10E-11	8.40E-12	1.05E-12	2.10E-13	9.45E-13	5.88E-13	7.00E-14	2.93E-13
Ra-226	1.88E-19	9.40E-17	3.76E-19	5.63E-18	2.25E-18	2.82E-19	5.63E-20	2.53E-19	1.58E-19	1.88E-20	7.87E-20
Ra-228	9.67E-21	4.84E-18	1.93E-20	2.90E-19	1.16E-19	1.45E-20	2.90E-21	1.31E-20	8.13E-21	9.67E-22	4.06E-21
Sr-90	7.46E-05	3.73E-02	1.49E-04	2.24E-03	8.95E-04	1.12E-04	2.24E-05	1.01E-04	6.27E-05	7.46E-06	3.13E-05
Tc-99	1.13E-08	5.63E-06	2.25E-08	3.38E-07	1.35E-07	1.69E-08	3.38E-09	1.52E-08	9.45E-09	1.13E-09	4.72E-09
Th-228	4.09E-13	2.05E-10	8.18E-13	1.23E-11	4.91E-12	6.13E-13	1.23E-13	5.52E-13	3.43E-13	4.09E-14	1.71E-13
Th-229	3.41E-18	1.71E-15	6.82E-18	1.02E-16	4.09E-17	5.11E-18	1.02E-18	4.60E-18	2.86E-18	3.41E-19	1.43E-18
Th-230	2.78E-16	1.39E-13	5.57E-16	8.35E-15	3.34E-15	4.18E-16	8.35E-17	3.76E-16	2.34E-16	2.78E-17	1.17E-16

Table A-9. (continued).

Waste Stream TRA-603-6N											
Isotope	1963	1964	1967	1970	1973	1974	1975	1976	1981	1985	1991
Th-232	6.35E-20	3.18E-17	1.27E-19	1.90E-18	7.62E-19	9.52E-20	1.90E-20	8.57E-20	5.33E-20	6.35E-21	2.66E-20
TRA-MFP	5.17E-05	2.59E-02	1.03E-04	1.55E-03	6.20E-04	7.75E-05	1.55E-05	6.98E-05	4.34E-05	5.17E-06	2.17E-05
U-232	8.28E-13	4.14E-10	1.66E-12	2.48E-11	9.93E-12	1.24E-12	2.48E-13	1.12E-12	6.95E-13	8.28E-14	3.47E-13
U-233	1.14E-14	5.70E-12	2.28E-14	3.41E-13	1.37E-13	1.71E-14	3.41E-15	1.54E-14	9.56E-15	1.14E-15	4.77E-15
U-234	1.08E-11	5.42E-09	2.17E-11	3.25E-10	1.30E-10	1.62E-11	3.25E-12	1.46E-11	9.10E-12	1.08E-12	4.54E-12
U-235	1.03E-10	5.16E-08	2.06E-10	3.09E-09	1.24E-09	1.55E-10	3.09E-11	1.39E-10	8.66E-11	1.03E-11	4.32E-11
U-236	3.92E-10	1.96E-07	7.84E-10	1.18E-08	4.70E-09	5.88E-10	1.18E-10	5.29E-10	3.29E-10	3.92E-11	1.64E-10
U-238	1.87E-12	9.36E-10	3.74E-12	5.61E-11	2.25E-11	2.81E-12	5.61E-13	2.53E-12	1.57E-12	1.87E-13	7.85E-13
TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.											

Waste Stream TRA-603-4N (1959-1968)										
Isotope	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Be-10	9.12E-06	1.73E-05	5.71E-05	4.49E-06	6.04E-05	2.68E-06	9.88E-05	1.82E-05	7.36E-07	4.93E-06
C-14	7.68E+00	3.42E+00	4.93E+01	9.26E+00	4.80E+01	3.22E+00	8.60E+01	1.71E+01	8.73E-01	5.37E+00
Cl-36	3.26E-08	4.10E-07	3.09E-08	1.04E-07	7.00E-07	6.20E-08	1.38E-07	1.68E-07	1.70E-08	1.14E-07
Co-60	1.27E+04	2.26E+04	6.87E+04	3.17E+04	1.19E+05	1.08E+04	1.27E+05	4.03E+04	2.97E+03	1.80E+04
Nb-94	1.62E+00	2.13E-01	1.08E+01	1.31E+00	8.86E+00	5.32E-01	1.86E+01	3.36E+00	1.45E-01	9.19E-01
Ni-59	8.60E+00	1.33E+01	4.21E+01	2.18E+01	8.58E+01	1.00E+01	8.32E+01	3.30E+01	2.76E+00	1.77E+01
Ni-63	1.96E+03	2.20E+03	1.00E+04	5.34E+03	1.88E+04	2.16E+03	1.94E+04	7.29E+03	5.94E+02	3.73E+03
Sr-90	2.59E-01	6.32E-02	3.63E-01	1.44E+00	4.26E+00	8.58E-01	1.75E+00	1.69E+00	2.25E-01	1.58E+00
Tc-99	8.95E-04	6.08E-04	5.60E-03	8.25E-04	5.68E-03	4.16E-04	9.88E-03	1.99E-03	1.11E-04	7.47E-04

Waste Stream TRA-603-4N (1969-1977)							
Isotope	1969	1970	1971	1972	1975	1976	1977
Be-10	2.32E-05	7.39E-05	2.50E-06	2.28E-07	2.44E-06	1.13E-05	1.29E-05
C-14	2.13E+01	1.06E+01	2.39E+00	4.29E-02	3.27E-01	1.51E+00	1.73E+00
Cl-36	1.06E-07	1.80E-06	5.78E-08	5.56E-09	5.95E-08	2.74E-07	3.15E-07
Co-60	3.92E+04	8.73E+04	9.79E+03	2.97E+02	2.82E+03	1.30E+04	1.49E+04
Nb-94	4.39E+00	2.17E-01	4.24E-01	2.54E-03	2.91E-03	1.34E-02	1.54E-02
Ni-59	2.94E+01	5.18E+01	9.34E+00	1.89E-01	1.64E+00	7.58E+00	8.71E+00
Ni-63	6.64E+03	7.80E+03	2.01E+03	3.08E+01	2.42E+02	1.12E+03	1.28E+03
Sr-90	1.44E+00	2.07E-01	2.59E-01	3.76E-03	8.86E-04	4.08E-03	4.69E-03
Tc-99	2.50E-03	2.37E-03	2.22E-04	8.53E-06	7.59E-05	3.50E-04	4.02E-04

Table A-9. (continued).

Waste Stream TRA-603-4N (1978-191993)						
Isotope	1978	1982	1987	1991	1992	1993
Be-10	5.02E-05	4.22E-05	1.24E-06	2.96E-07	1.36E-07	6.38E-07
C-14	3.64E+01	2.50E+01	1.47E+00	3.56E-01	1.63E-01	7.68E-01
Cl-36	2.49E-07	3.91E-07	2.88E-08	6.85E-09	3.14E-09	1.48E-08
Co-60	6.26E+04	5.17E+04	4.97E+03	1.20E+03	5.49E+02	2.58E+03
Nb-94	8.74E+00	5.73E+00	2.44E-01	5.88E-02	2.70E-02	1.27E-01
Ni-59	6.63E+01	4.97E+01	4.64E+00	1.11E+00	5.08E-01	2.39E+00
Ni-63	1.35E+04	9.74E+03	9.97E+02	2.39E+02	1.10E+02	5.15E+02
Sr-90	7.70E-01	5.07E-01	3.91E-01	9.48E-02	4.35E-02	2.04E-01
Tc-99	4.45E-03	3.20E-03	1.90E-04	4.60E-05	2.11E-05	9.91E-05

Table A-9. (continued).

Waste Stream TRA-603-28N (1959-1968)										
Isotope	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Am-241	2.18E-04	4.32E-03	2.56E-03	4.32E-04	2.14E-03	5.86E-03	3.13E-03	5.36E-03	8.21E-04	1.01E-04
Am-243	6.05E-07	1.20E-05	7.12E-06	1.20E-06	5.95E-06	1.63E-05	8.70E-06	1.49E-05	2.28E-06	2.81E-07
Be-10	8.81E-08	6.12E-07	6.25E-07	1.80E-07	8.79E-07	6.79E-08	1.52E-06	1.00E-07	2.63E-07	4.09E-08
C-14	6.68E-02	4.64E-01	5.10E-01	1.36E-01	6.66E-01	7.07E-02	1.15E+00	7.61E-02	2.00E-01	3.10E-02
Ce-144	4.24E+01	8.43E+02	4.99E+02	8.43E+01	4.17E+02	1.14E+03	6.10E+02	1.04E+03	1.60E+02	1.96E+01
Cl-36	3.39E-10	2.35E-09	2.40E-09	6.91E-10	3.38E-09	1.09E-09	5.84E-09	3.86E-10	1.01E-09	1.57E-10
Cm-243	2.03E-07	4.03E-06	2.38E-06	4.03E-07	1.99E-06	5.46E-06	2.91E-06	4.99E-06	7.64E-07	9.39E-08
Cm-244	1.78E-05	3.54E-04	2.09E-04	3.54E-05	1.75E-04	4.79E-04	2.56E-04	4.38E-04	6.71E-05	8.25E-06
Co-60	1.10E+02	7.66E+02	9.09E+02	2.25E+02	1.10E+03	2.05E+02	1.90E+03	1.26E+02	3.30E+02	5.11E+01
Cs-134	6.52E+00	1.30E+02	7.67E+01	1.30E+01	6.41E+01	1.76E+02	9.38E+01	1.61E+02	2.46E+01	3.02E+00
Cs-137	2.10E+01	4.17E+02	2.47E+02	4.17E+01	2.06E+02	5.64E+02	3.01E+02	5.16E+02	7.91E+01	9.72E+00
Eu-152	6.78E-04	1.35E-02	7.98E-03	1.35E-03	6.67E-03	1.83E-02	9.75E-03	1.67E-02	2.56E-03	3.14E-04
Eu-154	6.14E-01	1.22E+01	7.23E+00	1.22E+00	6.04E+00	1.65E+01	8.84E+00	1.51E+01	2.32E+00	2.85E-01
H-3	8.23E-02	1.64E+00	9.68E-01	1.64E-01	8.09E-01	2.22E+00	1.18E+00	2.03E+00	3.11E-01	3.82E-02
I-129	4.98E-06	9.91E-05	5.86E-05	9.91E-06	4.90E-05	1.34E-04	7.17E-05	1.23E-04	1.88E-05	2.31E-06
Nb-94	1.62E-02	1.13E-01	1.19E-01	3.31E-02	1.62E-01	1.31E-02	2.80E-01	1.85E-02	4.85E-02	7.52E-03
Ni-59	1.20E-01	8.31E-01	8.96E-01	2.44E-01	1.19E+00	1.95E-01	2.06E+00	1.36E-01	3.58E-01	5.55E-02
Ni-63	2.45E+01	1.70E+02	1.90E+02	4.99E+01	2.44E+02	4.17E+01	4.22E+02	2.79E+01	7.32E+01	1.13E+01
Np-237	4.11E-05	8.16E-04	4.83E-04	8.16E-05	4.04E-04	1.11E-03	5.91E-04	1.01E-03	1.55E-04	1.90E-05
Pm-147	3.03E+01	6.02E+02	3.56E+02	6.02E+01	2.98E+02	8.15E+02	4.35E+02	7.46E+02	1.14E+02	1.40E+01
Pu-238	7.80E-02	1.55E+00	9.17E-01	1.55E-01	7.67E-01	2.10E+00	1.12E+00	1.92E+00	2.94E-01	3.62E-02
Pu-239	4.26E-04	8.47E-03	5.01E-03	8.47E-04	4.19E-03	1.15E-02	6.13E-03	1.05E-02	1.61E-03	1.98E-04
Pu-240	3.46E-04	6.87E-03	4.07E-03	6.87E-04	3.40E-03	9.31E-03	4.97E-03	8.51E-03	1.30E-03	1.60E-04

Table A-9. (continued).

Waste Stream TRA-603-28N (1959-1968)										
Isotope	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Pu-241	4.07E-02	8.10E-01	4.79E-01	8.10E-02	4.01E-01	1.10E+00	5.86E-01	1.00E+00	1.54E-01	1.89E-02
Pu-242	1.89E-07	3.76E-06	2.22E-06	3.76E-07	1.86E-06	5.09E-06	2.72E-06	4.66E-06	7.13E-07	8.76E-08
Ra-226	5.07E-14	1.01E-12	5.97E-13	1.01E-13	4.99E-13	1.37E-12	7.30E-13	1.25E-12	1.91E-13	2.35E-14
Ra-228	2.61E-15	5.20E-14	3.07E-14	5.20E-15	2.57E-14	7.04E-14	3.76E-14	6.44E-14	9.86E-15	1.21E-15
Sr-90	2.02E+01	4.01E+02	2.37E+02	4.01E+01	1.98E+02	5.43E+02	2.90E+02	4.96E+02	7.60E+01	9.34E+00
Tc-99	3.04E-03	6.03E-02	3.57E-02	6.05E-03	2.99E-02	8.17E-02	4.37E-02	7.47E-02	1.15E-02	1.41E-03
Th-228	1.10E-07	2.20E-06	1.30E-06	2.20E-07	1.09E-06	2.97E-06	1.59E-06	2.72E-06	4.17E-07	5.12E-08
Th-229	9.21E-13	1.83E-11	1.08E-11	1.83E-12	9.05E-12	2.48E-11	1.32E-11	2.27E-11	3.47E-12	4.27E-13
Th-230	7.52E-11	1.50E-09	8.85E-10	1.50E-10	7.40E-10	2.03E-09	1.08E-09	1.85E-09	2.84E-10	3.49E-11
Th-232	1.71E-14	3.41E-13	2.02E-13	3.41E-14	1.69E-13	4.62E-13	2.47E-13	4.22E-13	6.47E-14	7.95E-15
TRA-MFP	1.40E+01	2.78E+02	1.64E+02	2.78E+01	1.37E+02	3.76E+02	2.01E+02	3.44E+02	5.27E+01	6.48E+00
U-232	2.24E-07	4.45E-06	2.63E-06	4.45E-07	2.20E-06	6.02E-06	3.22E-06	5.51E-06	8.44E-07	1.04E-07
U-233	3.07E-09	6.11E-08	3.62E-08	6.11E-09	3.02E-08	8.28E-08	4.42E-08	7.57E-08	1.16E-08	1.43E-09
U-234	2.93E-06	5.82E-05	3.44E-05	5.82E-06	2.88E-05	7.88E-05	4.21E-05	7.21E-05	1.10E-05	1.36E-06
U-235	2.79E-05	5.54E-04	3.28E-04	5.54E-05	2.74E-04	7.61E-04	4.24E-04	6.86E-04	1.05E-04	1.29E-05
U-236	1.06E-04	2.11E-03	1.25E-03	2.11E-04	1.04E-03	2.85E-03	1.52E-03	2.61E-03	4.00E-04	4.91E-05
U-238	5.06E-07	1.01E-05	5.95E-06	1.01E-06	4.97E-06	1.36E-05	7.27E-06	1.24E-05	1.91E-06	2.34E-07

TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.

Table A-9. (continued).

Waste Stream TRA-603-28N (1969-1978)										
Isotope	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Am-241	1.02E-04	7.89E-05	2.45E-05	9.72E-06	8.36E-06	5.13E-04	1.13E-04	1.30E-06	2.51E-07	8.31E-04
Am-243	2.84E-07	2.19E-07	6.81E-08	2.70E-08	2.32E-08	1.43E-06	3.13E-07	3.61E-09	6.98E-10	2.31E-06
Be-10	3.25E-08	3.19E-08	9.92E-09	3.94E-09	3.22E-09	4.13E-07	7.69E-08	5.26E-10	1.02E-10	3.03E-06
C-14	4.52E-02	2.42E-02	7.51E-03	2.98E-03	2.44E-03	3.13E-01	5.83E-02	3.98E-04	7.70E-05	2.30E+00
Ce-144	1.99E+01	1.54E+01	4.77E+00	1.89E+00	1.63E+00	9.99E+01	2.19E+01	2.53E-01	4.89E-02	1.62E+02
Cl-36	1.25E-10	1.23E-10	3.81E-11	1.51E-11	1.24E-11	1.59E-09	2.96E-10	2.02E-12	3.91E-13	1.16E-08
Cm-243	9.52E-08	7.35E-08	2.28E-08	9.05E-09	7.78E-09	4.78E-07	1.05E-07	1.21E-09	2.34E-10	7.74E-07
Cm-244	8.36E-06	6.45E-06	2.00E-06	7.95E-07	6.84E-07	4.20E-05	9.21E-06	1.06E-07	2.05E-08	6.80E-05
Co-60	1.13E+02	3.99E+01	1.24E+01	4.93E+00	4.03E+00	5.16E+02	9.62E+01	6.58E-01	1.27E-01	3.79E+03
Cs-134	3.06E+00	2.37E+00	7.34E-01	2.91E-01	2.50E-01	1.54E+01	3.37E+00	3.89E-02	7.52E-03	2.49E+01
Cs-137	9.85E+00	7.60E+00	2.36E+00	9.36E-01	8.05E-01	4.94E+01	1.08E+01	1.25E-01	2.42E-02	8.01E+01
Eu-152	3.19E-04	2.46E-04	7.63E-05	3.03E-05	2.60E-05	1.60E-03	3.51E-04	4.04E-06	7.82E-07	2.59E-03
Eu-154	2.89E-01	2.23E-01	6.91E-02	2.74E-02	2.36E-02	1.45E+00	3.18E-01	3.66E-03	7.09E-04	2.35E+00
H-3	3.87E-02	2.99E-02	9.26E-03	3.68E-03	3.16E-03	1.94E-01	4.26E-02	4.91E-04	9.50E-05	3.15E-01
I-129	2.34E-06	1.81E-06	5.61E-07	2.23E-07	1.91E-07	1.18E-05	2.58E-06	2.97E-08	5.75E-09	1.90E-05
Nb-94	8.19E-03	5.87E-03	1.82E-03	7.25E-04	5.92E-04	7.59E-02	1.42E-02	9.67E-05	1.87E-05	5.58E-01
Ni-59	7.10E-02	4.33E-02	1.35E-02	5.35E-03	4.37E-03	5.60E-01	1.04E-01	7.14E-04	1.38E-04	4.11E+00
Ni-63	1.82E+01	8.86E+00	2.75E+00	1.09E+00	8.94E-01	1.15E+02	2.14E+01	1.46E-01	2.82E-02	8.42E+02
Np-237	1.93E-05	1.49E-05	4.62E-06	1.83E-06	1.58E-06	9.68E-05	2.12E-05	2.45E-07	4.74E-08	1.57E-04
Pm-147	1.42E+01	1.10E+01	3.41E+00	1.35E+00	1.16E+00	7.14E+01	1.57E+01	1.81E-01	3.49E-02	1.16E+02
Pu-238	3.66E-02	2.83E-02	8.78E-03	3.48E-03	3.00E-03	1.84E-01	4.03E-02	4.65E-04	9.00E-05	2.98E-01

Table A-9. (continued).

Waste Stream TRA-603-28N (1969-1978)										
Isotope	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Pu-239	2.00E-04	1.55E-04	4.79E-05	1.90E-05	1.64E-05	1.00E-03	2.20E-04	2.54E-06	4.92E-07	1.63E-03
Pu-240	1.62E-04	1.25E-04	3.89E-05	1.54E-05	1.33E-05	8.15E-04	1.79E-04	2.06E-06	3.99E-07	1.32E-03
Pu-241	1.91E-02	1.48E-02	4.58E-03	1.82E-03	1.56E-03	9.61E-02	2.11E-02	2.43E-04	4.70E-05	1.56E-01
Pu-242	8.88E-08	6.86E-08	2.13E-08	8.45E-09	7.26E-09	4.46E-07	9.78E-08	1.13E-09	2.18E-10	7.22E-07
Ra-226	2.38E-14	1.84E-14	5.71E-15	2.27E-15	1.95E-15	1.20E-13	2.62E-14	3.03E-16	5.85E-17	1.94E-13
Ra-228	1.23E-15	9.48E-16	2.94E-16	1.17E-16	1.00E-16	6.16E-15	1.35E-15	1.56E-17	3.02E-18	9.99E-15
Sr-90	9.47E+00	7.31E+00	2.27E+00	9.00E-01	7.74E-01	4.75E+01	1.04E+01	1.20E-01	2.33E-02	7.70E+01
Tc-99	1.43E-03	1.10E-03	3.42E-04	1.36E-04	1.17E-04	7.19E-03	1.58E-03	1.81E-05	3.51E-06	1.19E-02
Th-228	5.19E-08	4.01E-08	1.24E-08	4.93E-09	4.24E-09	2.60E-07	5.71E-08	6.59E-10	1.27E-10	4.22E-07
Th-229	4.33E-13	3.34E-13	1.04E-13	4.11E-14	3.54E-14	2.17E-12	4.76E-13	5.49E-15	1.06E-15	3.52E-12
Th-230	3.53E-11	2.73E-11	8.46E-12	3.36E-12	2.89E-12	1.77E-10	3.89E-11	4.49E-13	8.68E-14	2.87E-10
Th-232	8.06E-15	6.22E-15	1.93E-15	7.66E-16	6.59E-16	4.04E-14	8.87E-15	1.02E-16	1.98E-17	6.55E-14
TRA-MFP	6.56E+00	5.07E+00	1.57E+00	6.24E-01	5.37E-01	3.29E+01	7.23E+00	8.33E-02	1.61E-02	5.34E+01
U-232	1.05E-07	8.11E-08	2.52E-08	9.99E-09	8.59E-09	5.27E-07	1.16E-07	1.33E-09	2.58E-10	8.54E-07
U-233	1.44E-09	1.12E-09	3.46E-10	1.37E-10	1.18E-10	7.25E-09	1.59E-09	1.83E-11	3.55E-12	1.17E-08
U-234	1.38E-06	1.06E-06	3.29E-07	1.31E-07	1.12E-07	6.90E-06	1.51E-06	1.75E-08	3.38E-09	1.12E-05
U-235	1.25E-03	1.01E-05	3.14E-06	1.24E-06	3.01E-05	6.57E-05	1.44E-05	1.66E-07	3.21E-08	1.06E-04
U-236	4.98E-05	3.84E-05	1.19E-05	4.73E-06	4.07E-06	2.50E-04	5.48E-05	6.32E-07	1.22E-07	4.05E-04
U-238	2.38E-07	1.83E-07	5.69E-08	2.26E-08	1.96E-03	1.19E-06	2.62E-07	3.02E-09	5.83E-10	1.93E-06

TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.

Table A-9. (continued).

Waste Stream TRA-603-28N (1979-1993)											
Isotope	1979	1980	1981	1982	1983	1984	1985	1986	1987	1989	1993
Am-241	2.35E-07	6.53E-07	6.53E-07	7.68E-02	1.65E-04	2.23E-04	1.19E-07	1.52E-07	1.06E-05	3.15E-07	6.86E-11
Am-243	6.54E-10	1.82E-09	1.82E-09	2.14E-04	4.59E-07	6.19E-07	3.30E-10	4.24E-10	2.96E-08	8.76E-10	1.91E-13
Be-10	9.53E-11	2.65E-10	2.65E-10	1.62E-06	9.42E-09	8.26E-08	4.81E-11	6.17E-11	4.32E-09	1.28E-10	2.78E-14
C-14	7.22E-05	2.00E-04	2.01E-04	1.23E+00	7.14E-03	6.26E-02	3.64E-05	4.67E-05	3.27E-03	9.67E-05	2.11E-08
Ce-144	4.58E-02	1.27E-01	1.27E-01	1.50E+04	3.22E+01	4.34E+01	2.31E-02	2.97E-02	2.08E+00	6.14E-02	1.34E-05
Cl-36	3.66E-13	1.02E-12	1.02E-12	6.24E-09	3.62E-11	3.17E-10	1.85E-13	2.37E-13	1.66E-11	4.91E-13	1.07E-16
Cm-243	2.19E-10	6.08E-10	6.09E-10	7.15E-05	1.54E-07	2.07E-07	1.10E-10	1.42E-10	9.92E-09	2.93E-10	6.39E-14
Cm-244	1.92E-08	5.34E-08	5.35E-08	6.28E-03	1.35E-05	1.82E-05	9.70E-09	1.25E-08	8.71E-07	2.58E-08	5.61E-12
Co-60	1.19E-01	3.31E-01	3.31E-01	2.03E+03	1.18E+01	1.03E+02	6.01E-02	7.72E-02	5.40E+00	1.60E-01	3.48E-05
Cs-134	7.05E-03	1.96E-02	1.96E-02	2.30E+03	4.95E+00	6.68E+00	3.56E-03	4.56E-03	3.19E-01	9.44E-03	2.06E-06
Cs-137	2.26E-02	6.29E-02	6.30E-02	7.40E+03	1.59E+01	2.15E+01	1.14E-02	1.47E-02	1.03E+00	3.03E-02	6.61E-06
Eu-152	7.33E-07	2.04E-06	2.04E-06	2.39E-01	5.14E-04	6.94E-04	3.70E-07	4.75E-07	3.32E-05	9.82E-07	2.14E-10
Eu-154	6.64E-04	1.84E-03	1.85E-03	2.17E+02	4.66E-01	6.29E-01	3.35E-04	4.30E-04	3.01E-02	8.90E-04	1.94E-07
H-3	8.89E-05	2.47E-04	2.47E-04	2.90E+01	6.25E-02	8.43E-02	4.49E-05	5.76E-05	4.03E-03	1.19E-04	2.60E-08
I-129	5.39E-09	1.50E-08	1.50E-08	1.76E-03	3.78E-06	5.10E-06	2.72E-09	3.49E-09	2.44E-07	7.22E-09	1.57E-12
Nb-94	1.75E-05	4.87E-05	4.87E-05	2.99E-01	1.73E-03	1.52E-02	8.84E-06	1.14E-05	7.94E-04	2.35E-05	5.11E-09
Ni-59	1.29E-04	3.59E-04	3.60E-04	2.20E+00	1.28E-02	1.12E-01	6.52E-05	8.38E-05	5.86E-03	1.73E-04	3.77E-08
Ni-63	2.65E-02	7.35E-02	7.35E-02	4.51E+02	2.62E+00	2.29E+01	1.33E-02	1.71E-02	1.20E+00	3.54E-02	7.72E-06
Np-237	4.44E-08	1.23E-07	1.23E-07	1.45E-02	3.12E-05	4.20E-05	2.24E-08	2.87E-08	2.01E-06	5.95E-08	1.29E-11
Pm-147	3.27E-02	9.09E-02	9.10E-02	1.07E+04	2.30E+01	3.10E+01	1.65E-02	2.12E-02	1.48E+00	4.38E-02	9.55E-06
Pu-238	8.43E-05	2.34E-04	2.34E-04	2.75E+01	5.92E-02	7.98E-02	4.25E-05	5.46E-05	3.82E-03	1.13E-04	2.46E-08

Table A-9. (continued).

Waste Stream TRA-603-28N (1979-1993)											
Isotope	1979	1980	1981	1982	1983	1984	1985	1986	1987	1989	1993
Pu-239	4.60E-07	1.28E-06	1.28E-06	1.50E-01	3.23E-04	4.36E-04	2.32E-07	2.98E-07	2.09E-05	6.17E-07	1.34E-10
Pu-240	3.74E-07	1.04E-06	1.04E-06	1.22E-01	2.62E-04	3.54E-04	1.88E-07	2.42E-07	1.69E-05	5.01E-07	1.09E-10
Pu-241	4.40E-05	1.22E-04	1.22E-04	1.44E+01	3.09E-02	4.17E-02	2.22E-05	2.85E-05	1.99E-03	5.90E-05	1.28E-08
Pu-242	2.04E-10	5.67E-10	5.68E-10	6.67E-05	1.43E-07	1.93E-07	1.03E-10	1.32E-10	9.26E-09	2.74E-10	5.96E-14
Ra-226	5.48E-17	1.52E-16	1.52E-16	1.79E-11	3.85E-14	5.19E-14	2.77E-17	3.55E-17	2.48E-15	7.35E-17	1.60E-20
Ra-228	2.82E-18	7.84E-18	7.85E-18	9.22E-13	1.98E-15	2.68E-15	1.42E-18	1.83E-18	1.28E-16	3.78E-18	8.24E-22
Sr-90	2.18E-02	6.05E-02	6.05E-02	7.11E+03	1.53E+01	2.06E+01	1.10E-02	1.41E-02	9.87E-01	2.92E-02	6.36E-06
Tc-99	3.29E-06	9.12E-06	9.13E-06	1.07E+00	2.30E-03	3.11E-03	1.66E-06	2.13E-06	1.49E-04	4.40E-06	9.59E-10
Th-228	1.19E-10	3.31E-10	3.32E-10	3.90E-05	8.38E-08	1.13E-07	6.02E-11	7.73E-11	5.41E-09	1.60E-10	3.48E-14
Th-229	9.95E-16	2.76E-15	2.77E-15	3.25E-10	6.99E-13	9.43E-13	5.02E-16	6.45E-16	4.51E-14	1.33E-15	2.90E-19
Th-230	8.13E-14	2.26E-13	2.26E-13	2.65E-08	5.71E-11	7.70E-11	4.10E-14	5.27E-14	3.68E-12	1.09E-13	2.37E-17
Th-232	1.85E-17	5.15E-17	5.15E-17	6.05E-12	1.30E-14	1.76E-14	9.35E-18	1.20E-17	8.40E-16	2.48E-17	5.41E-21
TRA-MFP	1.51E-02	4.19E-02	4.20E-02	4.93E+03	1.06E+01	1.43E+01	7.61E-03	9.78E-03	6.84E-01	2.02E-02	4.40E-06
U-232	2.42E-10	6.71E-10	6.72E-10	7.89E-05	1.70E-07	2.29E-07	1.22E-10	1.57E-10	1.09E-08	3.24E-10	7.05E-14
U-233	3.32E-12	9.23E-12	9.24E-12	1.09E-06	2.33E-09	3.15E-09	1.68E-12	2.15E-12	1.51E-10	4.45E-12	9.70E-16
U-234	3.16E-09	8.78E-09	8.79E-09	1.03E-03	2.22E-06	3.00E-06	1.60E-09	2.05E-09	1.43E-07	4.24E-09	9.23E-13
U-235	3.01E-08	8.36E-08	8.37E-08	9.83E-03	2.11E-05	2.85E-05	1.52E-08	1.95E-08	1.36E-06	4.03E-08	8.79E-12
U-236	1.14E-07	3.18E-07	3.18E-07	3.74E-02	8.04E-05	1.08E-04	5.77E-08	7.41E-08	5.19E-06	1.53E-07	3.34E-11
U-238	5.46E-10	1.52E-09	1.52E-09	1.78E-04	3.84E-07	5.17E-07	2.76E-10	3.54E-10	2.47E-08	7.32E-10	1.59E-13
TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.											

Table A-9. (continued).

Waste Stream TRA-603-27N																
Isotope	1969	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1984	1985	1986
Am-241	8.05E-11	8.05E-09	8.49E-08	2.50E-07	6.84E-07	1.38E-05	2.31E-05	1.93E-05	4.21E-04	1.03E-05	7.86E-06	5.68E-06	8.05E-10	1.07E-05	4.79E-05	5.04E-06
Am-243	2.24E-13	2.24E-11	2.36E-10	6.96E-10	1.90E-09	3.84E-08	6.42E-08	5.36E-08	1.17E-06	2.87E-08	2.19E-08	1.58E-08	2.24E-12	2.98E-08	1.33E-07	1.40E-08
Be-10	3.26E-14	3.26E-12	3.44E-11	1.01E-10	2.77E-10	5.59E-09	9.36E-09	7.81E-09	3.70E-05	4.19E-09	3.19E-09	2.30E-09	3.26E-13	4.33E-09	1.94E-08	2.04E-09
C-14	2.47E-08	2.47E-06	2.61E-05	7.68E-05	2.10E-04	4.24E-03	7.09E-03	5.92E-03	2.81E+01	3.17E-03	2.41E-03	1.74E-03	2.47E-07	3.28E-03	1.47E-02	1.55E-03
Ce-144	1.57E-05	1.57E-03	1.66E-02	4.87E-02	1.33E-01	2.69E+00	4.50E+00	3.76E+00	8.21E+01	2.01E+00	1.53E+00	1.11E+00	1.57E-04	2.08E+00	9.33E+00	9.82E-01
Cl-36	1.25E-16	1.25E-14	1.32E-13	3.90E-13	1.06E-12	2.15E-11	3.60E-11	3.00E-11	1.42E-07	1.61E-11	1.22E-11	8.85E-12	1.25E-15	1.67E-11	7.45E-11	7.85E-12
Cm-243	7.50E-14	7.50E-12	7.91E-11	2.33E-10	6.37E-10	1.29E-08	2.15E-08	1.80E-08	3.93E-07	9.62E-09	7.32E-09	5.29E-09	7.50E-13	9.96E-09	4.46E-08	4.69E-09
Cm-244	6.59E-12	6.59E-10	6.95E-09	2.05E-08	5.59E-08	1.13E-06	1.89E-06	1.58E-06	3.45E-05	8.45E-07	6.43E-07	4.65E-07	6.59E-11	8.75E-07	3.92E-06	4.12E-07
Co-60	4.08E-05	4.08E-03	4.31E-02	1.27E-01	3.47E-01	7.00E+00	1.17E+01	9.77E+00	4.64E+04	5.24E+00	3.99E+00	2.88E+00	4.08E-04	5.42E+00	2.43E+01	2.55E+00
Cs-134	2.41E-06	2.41E-04	2.55E-03	7.50E-03	2.05E-02	4.14E-01	6.92E-01	5.78E-01	1.26E+01	3.10E-01	2.36E-01	1.70E-01	2.41E-05	3.21E-01	1.43E+00	1.51E-01
Cs-137	7.76E-06	7.76E-04	8.19E-03	2.41E-02	6.59E-02	1.33E+00	2.22E+00	1.86E+00	4.06E+01	9.95E-01	7.58E-01	5.47E-01	7.76E-05	1.03E+00	4.61E+00	4.85E-01
Eu-152	2.51E-10	2.51E-08	2.65E-07	7.80E-07	2.13E-06	4.30E-05	7.20E-05	6.01E-05	1.31E-03	3.22E-05	2.45E-05	1.77E-05	2.51E-09	3.33E-05	1.49E-04	1.57E-05
Eu-154	2.27E-07	2.27E-05	2.40E-04	7.06E-04	1.93E-03	3.90E-02	6.52E-02	5.45E-02	1.19E+00	2.92E-02	2.22E-02	1.60E-02	2.27E-06	3.02E-02	1.35E-01	1.42E-02
H-3	3.05E-08	3.05E-06	3.21E-05	9.47E-05	2.59E-04	5.22E-03	8.74E-03	7.30E-03	1.60E-01	3.91E-03	2.97E-03	2.15E-03	3.05E-07	4.05E-03	1.81E-02	1.91E-03
I-129	1.84E-12	1.84E-10	1.95E-09	5.73E-09	1.57E-08	3.16E-07	5.29E-07	4.42E-07	9.66E-06	2.37E-07	1.80E-07	1.30E-07	1.84E-11	2.45E-07	1.10E-06	1.15E-07
Nb-94	6.00E-09	6.00E-07	6.33E-06	1.86E-05	5.10E-05	1.03E-03	1.72E-03	1.44E-03	6.82E+00	7.70E-04	5.86E-04	4.24E-04	6.00E-08	7.97E-04	3.57E-03	3.76E-04
Ni-59	4.43E-08	4.43E-06	4.67E-05	1.38E-04	3.76E-04	7.59E-03	1.27E-02	1.06E-02	5.03E+01	5.68E-03	4.33E-03	3.13E-03	4.43E-07	5.88E-03	2.63E-02	2.77E-03
Ni-63	9.06E-06	9.06E-04	9.56E-03	2.81E-02	7.69E-02	1.55E+00	2.60E+00	2.17E+00	1.03E+04	1.16E+00	8.85E-01	6.39E-01	9.06E-05	1.20E+00	5.39E+00	5.67E-01
Np-237	1.52E-11	1.52E-09	1.60E-08	4.72E-08	1.29E-07	2.61E-06	4.36E-06	3.64E-06	7.96E-05	1.95E-06	1.48E-06	1.07E-06	1.52E-10	2.02E-06	9.04E-06	9.51E-07
Pm-147	1.12E-05	1.12E-03	1.18E-02	3.48E-02	9.52E-02	1.92E+00	3.21E+00	2.68E+00	5.87E+01	1.44E+00	1.09E+00	7.91E-01	1.12E-04	1.49E+00	6.66E+00	7.01E-01
Pu-238	2.89E-08	2.89E-06	3.05E-05	8.97E-05	2.45E-04	4.95E-03	8.28E-03	6.91E-03	1.51E-01	3.70E-03	2.82E-03	2.04E-03	2.89E-07	3.83E-03	1.72E-02	1.81E-03
Pu-239	1.58E-10	1.58E-08	1.66E-07	4.90E-07	1.34E-06	2.70E-05	4.52E-05	3.78E-05	8.26E-04	2.02E-05	1.54E-05	1.11E-05	1.58E-09	2.09E-05	9.37E-05	9.87E-06
Pu-240	1.28E-10	1.28E-08	1.35E-07	3.98E-07	1.09E-06	2.19E-05	3.67E-05	3.06E-05	6.70E-04	1.64E-05	1.25E-05	9.03E-06	1.28E-09	1.70E-05	7.61E-05	8.01E-06
Pu-241	1.51E-08	1.51E-06	1.59E-05	4.69E-05	1.28E-04	2.59E-03	4.32E-03	3.61E-03	7.89E-02	1.93E-03	1.47E-03	1.06E-03	1.51E-07	2.00E-03	8.96E-03	9.44E-04
Pu-242	7.00E-14	7.00E-12	7.38E-11	2.17E-10	5.94E-10	1.20E-08	2.01E-08	1.68E-08	3.66E-07	8.98E-09	6.83E-09	4.94E-09	7.00E-13	9.29E-09	4.16E-08	4.38E-09
Ra-226	1.88E-20	1.88E-18	1.98E-17	5.83E-17	1.59E-16	3.22E-15	5.39E-15	4.50E-15	9.83E-14	2.41E-15	1.83E-15	1.33E-15	1.88E-19	2.49E-15	1.12E-14	1.18E-15
Ra-228	9.67E-22	9.67E-20	1.02E-18	3.01E-18	8.21E-18	1.66E-16	2.77E-16	2.32E-16	5.07E-15	1.24E-16	9.45E-17	6.83E-17	9.67E-21	1.28E-16	5.75E-16	6.05E-17

Table A-9. (continued).

Waste Stream TRA-603-27N																
Isotope	1969	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1984	1985	1986
Sr-90	7.46E-06	7.46E-04	7.87E-03	2.32E-02	6.33E-02	1.28E+00	2.14E+00	1.79E+00	3.97E+01	9.57E-01	7.28E-01	5.26E-01	7.46E-05	9.91E-01	4.43E+00	4.67E-01
Tc-99	1.13E-09	1.13E-07	1.19E-06	3.50E-06	9.55E-06	1.93E-04	3.23E-04	2.69E-04	9.28E-03	1.44E-04	1.10E-04	7.94E-05	1.13E-08	1.49E-04	6.69E-04	7.04E-05
Th-228	4.09E-14	4.09E-12	4.31E-11	1.27E-10	3.47E-10	7.01E-09	1.17E-08	9.79E-09	2.14E-07	5.24E-09	3.99E-09	2.88E-09	4.09E-13	5.43E-09	2.43E-08	2.56E-09
Th-229	3.41E-19	3.41E-17	3.60E-16	1.06E-15	2.89E-15	5.84E-14	9.77E-14	8.16E-14	1.78E-12	4.37E-14	3.33E-14	2.41E-14	3.41E-18	4.53E-14	2.03E-13	2.13E-14
Th-230	2.78E-17	2.78E-15	2.94E-14	8.65E-14	2.36E-13	4.77E-12	7.99E-12	6.67E-12	1.46E-10	3.57E-12	2.72E-12	1.97E-12	2.78E-16	3.70E-12	1.66E-11	1.74E-12
Th-232	6.35E-21	6.35E-19	6.70E-18	1.97E-17	5.39E-17	1.09E-15	1.82E-15	1.52E-15	3.32E-14	8.14E-16	6.20E-16	4.48E-16	6.35E-20	8.43E-16	3.77E-15	3.97E-16
TRA-MFP	5.17E-06	5.17E-04	5.45E-03	1.61E-02	4.39E-02	8.86E-01	1.48E+00	1.24E+00	2.71E+01	6.63E-01	5.05E-01	3.65E-01	5.17E-05	6.87E-01	3.07E+00	3.24E-01
U-232	8.28E-14	8.28E-12	8.73E-11	2.57E-10	7.03E-10	1.42E-08	2.37E-08	1.98E-08	4.33E-07	1.06E-08	8.08E-09	5.84E-09	8.28E-13	1.10E-08	4.92E-08	5.18E-09
U-233	1.14E-15	1.14E-13	1.20E-12	3.54E-12	9.66E-12	1.95E-10	3.26E-10	2.73E-10	5.96E-09	1.46E-10	1.11E-10	8.03E-11	1.14E-14	1.51E-10	6.77E-10	7.12E-11
U-234	1.08E-12	1.08E-10	1.14E-09	3.37E-09	9.20E-09	1.86E-07	3.11E-07	2.59E-07	5.67E-06	1.39E-07	1.06E-07	7.64E-08	1.08E-11	1.44E-07	6.44E-07	6.78E-08
U-235	1.03E-11	1.03E-09	1.09E-08	3.20E-08	8.76E-08	1.77E-06	2.96E-06	2.47E-06	5.40E-05	1.32E-06	1.01E-06	7.28E-07	1.03E-10	1.37E-06	6.13E-06	6.45E-07
U-236	3.92E-11	3.92E-09	4.14E-08	1.22E-07	3.33E-07	6.72E-06	1.12E-05	9.39E-06	2.05E-04	5.03E-06	3.83E-06	2.77E-06	3.92E-10	5.21E-06	2.33E-05	2.45E-06
U-238	1.87E-13	1.87E-11	1.97E-10	5.81E-10	1.59E-09	3.21E-08	5.37E-08	4.48E-08	9.80E-07	2.40E-08	1.83E-08	1.32E-08	1.87E-12	2.49E-08	1.11E-07	1.17E-08
TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.																

Table A-9. (continued).

Waste Stream TRA-603-26N		
Isotope	1962	1976
Am-241	8.05E-11	2.23E-10
Am-243	2.24E-13	6.20E-13
Be-10	3.26E-14	9.03E-14
C-14	2.47E-08	6.84E-08
Ce-144	1.57E-05	4.34E-05
Cl-36	1.25E-16	3.47E-16
Cm-243	7.50E-14	2.08E-13
Cm-244	6.59E-12	1.82E-11
Co-60	4.08E-05	1.13E-04
Cs-134	2.41E-06	6.68E-06
Cs-137	7.76E-06	2.15E-05
Eu-152	2.51E-10	6.95E-10
Eu-154	2.27E-07	6.29E-07
H-3	3.05E-08	8.43E-08
I-129	1.84E-12	5.11E-12
Nb-94	6.00E-09	1.66E-08
Ni-59	4.43E-08	1.23E-07
Ni-63	9.06E-06	2.51E-05
Np-237	1.52E-11	4.21E-11
Pm-147	1.12E-05	3.10E-05
Pu-238	2.89E-08	7.99E-08
Pu-239	1.58E-10	4.37E-10
Pu-240	1.28E-10	3.54E-10
Pu-241	1.51E-08	4.17E-08
Pu-242	7.00E-14	1.94E-13
Ra-226	1.88E-20	5.20E-20
Ra-228	9.67E-22	2.68E-21
Sr-90	7.46E-06	2.06E-05
Tc-99	1.13E-09	3.11E-09
Th-228	4.09E-14	1.13E-13
Th-229	3.41E-19	9.43E-19

Table A-9. (continued).

Waste Stream TRA-603-26N		
Isotope	1962	1976
Th-230	2.78E-17	7.71E-17
Th-232	6.35E-21	1.76E-20
TRA-MFP	5.17E-06	1.43E-05
U-232	8.28E-14	2.29E-13
U-233	1.14E-15	3.15E-15
U-234	1.08E-12	3.00E-12
U-235	1.03E-11	2.85E-11
U-236	3.92E-11	1.09E-10
U-238	1.87E-13	5.18E-13

TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.

Table A-9. (continued).

Waste Stream TRA-603-21N																	
Isotope	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1973	1975	1986	1987	1992
Am-241	4.80E-07	2.93E-07	4.35E-07	5.64E-08	4.07E-09	3.31E-07	2.94E-08	8.05E-12	2.12E-09	6.44E-10	8.05E-10	1.83E-08	3.56E-08	1.41E-07	5.49E-07	1.59E-12	7.66E-16
Am-243	1.34E-09	8.16E-10	1.21E-09	1.57E-10	1.13E-11	9.21E-10	8.18E-11	2.24E-14	5.89E-12	1.79E-12	2.24E-12	5.08E-11	9.91E-11	3.92E-10	1.53E-09	4.42E-15	2.13E-18
Be-10	1.79E-10	9.86E-11	1.76E-10	2.22E-11	1.65E-12	3.59E-12	1.19E-11	3.26E-15	6.53E-13	2.61E-13	3.26E-13	7.40E-12	1.44E-11	5.71E-11	2.23E-10	6.44E-16	3.11E-19
C-14	1.36E-04	7.47E-05	1.33E-04	1.68E-05	1.25E-06	2.72E-06	9.02E-06	2.47E-09	4.94E-07	1.98E-07	2.47E-07	5.61E-06	1.09E-05	4.33E-05	1.69E-04	4.88E-10	2.35E-13
Ce-144	9.35E-02	5.71E-02	8.47E-02	1.10E-02	7.92E-04	6.45E-02	5.73E-03	1.57E-06	4.13E-04	1.26E-04	1.57E-04	3.56E-03	6.94E-03	2.75E-02	1.07E-01	3.10E-07	1.49E-10
Cl-36	6.90E-13	3.79E-13	6.77E-13	8.53E-14	6.33E-15	1.38E-14	4.58E-14	1.25E-17	2.51E-15	1.00E-15	1.25E-15	2.85E-14	5.55E-14	2.20E-13	8.55E-13	2.48E-18	1.19E-21
Cm-243	4.47E-10	2.73E-10	4.05E-10	5.25E-11	3.79E-12	3.08E-10	2.74E-11	7.50E-15	1.97E-12	6.00E-13	7.50E-13	1.70E-11	3.32E-11	1.31E-10	5.12E-10	1.48E-15	7.14E-19
Cm-244	3.93E-08	2.40E-08	3.56E-08	4.61E-09	3.33E-10	2.71E-08	2.40E-09	6.59E-13	1.73E-10	5.27E-11	6.59E-11	1.49E-09	2.91E-09	1.15E-08	4.49E-08	1.30E-13	6.27E-17
Co-60	2.25E-01	1.23E-01	2.20E-01	2.78E-02	2.06E-03	4.49E-03	1.49E-02	4.08E-06	8.16E-04	3.27E-04	4.08E-04	9.26E-03	1.81E-02	7.15E-02	2.78E-01	8.06E-07	3.89E-10
Cs-134	1.44E-02	8.79E-03	1.30E-02	1.69E-03	1.22E-04	9.92E-03	8.81E-04	2.41E-07	6.35E-05	1.93E-05	2.41E-05	5.48E-04	1.07E-03	4.23E-03	1.65E-02	4.76E-08	2.30E-11
Cs-137	4.62E-02	2.83E-02	4.19E-02	5.43E-03	3.92E-04	3.19E-02	2.83E-03	7.76E-07	2.04E-04	6.21E-05	7.76E-05	1.76E-03	3.43E-03	1.36E-02	5.29E-02	1.53E-07	7.38E-11
Eu-152	1.50E-06	9.14E-07	1.36E-06	1.76E-07	1.27E-08	1.03E-06	9.16E-08	2.51E-11	6.60E-09	2.01E-09	2.51E-09	5.70E-08	1.11E-07	4.39E-07	1.71E-06	4.95E-12	2.39E-15
Eu-154	1.36E-03	8.28E-04	1.23E-03	1.59E-04	1.15E-05	9.35E-04	8.30E-05	2.27E-08	5.98E-06	1.82E-06	2.27E-06	5.16E-05	1.01E-04	3.98E-04	1.55E-03	4.49E-09	2.16E-12
H-3	1.82E-04	1.11E-04	1.65E-04	2.13E-05	1.54E-06	1.25E-04	1.11E-05	3.05E-09	8.01E-07	2.44E-07	3.05E-07	6.91E-06	1.35E-05	5.33E-05	2.08E-04	6.01E-10	2.90E-13
I-129	1.10E-08	6.72E-09	9.96E-09	1.29E-09	9.32E-11	7.58E-09	6.73E-10	1.84E-13	4.85E-11	1.48E-11	1.84E-11	4.19E-10	8.16E-10	3.23E-09	1.26E-08	3.64E-14	1.76E-17
Nb-94	3.30E-05	1.81E-05	3.24E-05	4.08E-06	3.03E-07	6.60E-07	2.19E-06	6.00E-10	1.20E-07	4.80E-08	6.00E-08	1.36E-06	2.66E-06	1.05E-05	4.09E-05	1.18E-10	5.71E-14
Ni-59	2.44E-04	1.34E-04	2.39E-04	3.01E-05	2.24E-06	4.87E-06	1.62E-05	4.43E-09	8.86E-07	3.54E-07	4.43E-07	1.01E-05	1.96E-05	7.76E-05	3.02E-04	8.74E-10	4.22E-13
Ni-63	4.98E-02	2.74E-02	4.89E-02	6.16E-03	4.58E-04	9.97E-04	3.31E-03	9.06E-07	1.81E-04	7.25E-05	9.06E-05	2.06E-03	4.01E-03	1.59E-02	6.18E-02	1.79E-07	8.62E-11
Np-237	9.06E-08	5.54E-08	8.21E-08	1.06E-08	7.68E-10	6.25E-08	5.55E-09	1.52E-12	4.00E-10	1.22E-10	1.52E-10	3.45E-09	6.73E-09	2.66E-08	1.04E-07	3.00E-13	1.45E-16
Pm-147	6.68E-02	4.08E-02	6.05E-02	7.85E-03	5.66E-04	4.61E-02	4.09E-03	1.12E-06	2.95E-04	8.97E-05	1.12E-04	2.54E-03	4.96E-03	1.96E-02	7.65E-02	2.21E-07	1.07E-10
Pu-238	1.72E-04	1.05E-04	1.56E-04	2.02E-05	1.46E-06	1.19E-04	1.05E-05	2.89E-09	7.59E-07	2.31E-07	2.89E-07	6.55E-06	1.28E-05	5.05E-05	1.97E-04	5.70E-10	2.75E-13
Pu-239	9.40E-07	5.74E-07	8.52E-07	1.10E-07	7.96E-09	6.48E-07	5.76E-08	1.58E-11	4.15E-09	1.26E-09	1.58E-09	3.58E-08	6.98E-08	2.76E-07	1.08E-06	3.11E-12	1.50E-15
Pu-240	7.63E-07	4.66E-07	6.91E-07	8.96E-08	6.46E-09	5.26E-07	4.67E-08	1.28E-11	3.36E-09	1.02E-09	1.28E-09	2.90E-08	5.66E-08	2.24E-07	8.73E-07	2.53E-12	1.22E-15
Pu-241	8.99E-05	5.49E-05	8.14E-05	1.06E-05	7.62E-07	6.20E-05	5.50E-06	1.51E-09	3.97E-07	1.21E-07	1.51E-07	3.42E-06	6.67E-06	2.64E-05	1.03E-04	2.98E-10	1.44E-13
Pu-242	4.17E-10	2.55E-10	3.78E-10	4.90E-11	3.53E-12	2.88E-10	2.55E-11	7.00E-15	1.84E-12	5.60E-13	7.00E-13	1.59E-11	3.10E-11	1.22E-10	4.77E-10	1.38E-15	6.66E-19
Ra-226	1.12E-16	6.84E-17	1.01E-16	1.31E-17	9.48E-19	7.72E-17	6.85E-18	1.88E-21	4.94E-19	1.50E-19	1.88E-19	4.26E-18	8.31E-18	3.29E-17	1.28E-16	3.71E-22	1.79E-25
Ra-228	5.77E-18	3.52E-18	5.22E-18	6.77E-19	4.89E-20	3.98E-18	3.53E-19	9.67E-23	2.54E-20	7.74E-21	9.67E-21	2.20E-19	4.28E-19	1.69E-18	6.60E-18	1.91E-23	9.21E-27

Table A-9. (continued).

Waste Stream TRA-603-21N																	
Isotope	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1973	1975	1986	1987	1992
Sr-90	4.45E-02	2.72E-02	4.03E-02	5.22E-03	3.77E-04	3.07E-02	2.72E-03	7.46E-07	1.96E-04	5.97E-05	7.46E-05	1.69E-03	3.30E-03	1.31E-02	5.09E-02	1.47E-07	7.10E-11
Tc-99	6.71E-06	4.10E-06	6.08E-06	7.88E-07	5.68E-08	4.61E-06	4.11E-07	1.13E-10	2.96E-08	9.00E-09	1.13E-08	2.55E-07	4.98E-07	1.97E-06	7.68E-06	2.22E-11	1.07E-14
Th-228	2.44E-10	1.49E-10	2.21E-10	2.86E-11	2.06E-12	1.68E-10	1.49E-11	4.09E-15	1.08E-12	3.27E-13	4.09E-13	9.28E-12	1.81E-11	7.16E-11	2.79E-10	8.07E-16	3.89E-19
Th-229	2.03E-15	1.24E-15	1.84E-15	2.39E-16	1.72E-17	1.40E-15	1.24E-16	3.41E-20	8.96E-18	2.73E-18	3.41E-18	7.73E-17	1.51E-16	5.97E-16	2.32E-15	6.73E-21	3.24E-24
Th-230	1.66E-13	1.01E-13	1.50E-13	1.95E-14	1.41E-15	1.14E-13	1.02E-14	2.78E-18	7.32E-16	2.23E-16	2.78E-16	6.32E-15	1.23E-14	4.87E-14	1.90E-13	5.50E-19	2.65E-22
Th-232	3.78E-17	2.31E-17	3.43E-17	4.44E-18	3.21E-19	2.61E-17	2.32E-18	6.35E-22	1.67E-19	5.08E-20	6.35E-20	1.44E-18	2.81E-18	1.11E-17	4.33E-17	1.25E-22	6.04E-26
TRA-MFP	3.08E-02	1.88E-02	2.79E-02	3.62E-03	2.61E-04	2.12E-02	1.89E-03	5.17E-07	1.36E-04	4.14E-05	5.17E-05	1.17E-03	2.29E-03	9.05E-03	3.53E-02	1.02E-07	4.92E-11
U-232	4.93E-10	3.01E-10	4.47E-10	5.79E-11	4.18E-12	3.40E-10	3.02E-11	8.28E-15	2.18E-12	6.62E-13	8.28E-13	1.88E-11	3.66E-11	1.45E-10	5.65E-10	1.63E-15	7.88E-19
U-233	6.78E-12	4.14E-12	6.15E-12	7.97E-13	5.75E-14	4.68E-12	4.15E-13	1.14E-16	2.99E-14	9.10E-15	1.14E-14	2.58E-13	5.04E-13	1.99E-12	7.76E-12	2.25E-17	1.08E-20
U-234	6.46E-09	3.95E-09	5.85E-09	7.58E-10	5.47E-11	4.45E-09	3.95E-10	1.08E-13	2.85E-11	8.67E-12	1.08E-11	2.46E-10	4.79E-10	1.90E-09	7.39E-09	2.14E-14	1.03E-17
U-235	6.15E-08	3.76E-08	5.57E-08	7.22E-09	5.21E-10	4.24E-08	3.76E-09	1.03E-12	2.71E-10	8.25E-11	1.03E-10	2.34E-09	4.56E-09	1.81E-08	7.03E-08	2.04E-13	9.82E-17
U-236	2.34E-07	1.43E-07	2.12E-07	2.74E-08	1.98E-09	1.61E-07	1.43E-08	3.92E-12	1.03E-09	3.14E-10	3.92E-10	8.89E-09	1.73E-08	6.86E-08	2.67E-07	7.74E-13	3.73E-16
U-238	1.12E-09	6.81E-10	1.01E-09	1.31E-10	9.45E-12	7.69E-10	6.83E-11	1.87E-14	4.92E-12	1.50E-12	1.87E-12	4.25E-11	8.28E-11	3.28E-10	1.28E-09	3.69E-15	1.78E-18
TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.																	

Table A-9. (continued).

Waste Stream TRA-603-1N (1960-1970)											
Isotope	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Am-241	1.50E-05	1.50E-05	1.50E-05	1.50E-05	1.50E-05	1.50E-05	1.50E-05	1.50E-05	1.50E-05	2.16E-05	2.77E-05
C-14	1.09E-02	1.09E-02	1.09E-02	1.09E-02	1.09E-02	1.09E-02	1.09E-02	1.09E-02	1.09E-02	1.57E-02	2.01E-02
Cm-242	1.78E-05	1.78E-05	1.78E-05	1.78E-05	1.78E-05	1.78E-05	1.78E-05	1.78E-05	1.78E-05	2.56E-05	3.28E-05
Cm-244	8.08E-05	8.08E-05	8.08E-05	8.08E-05	8.08E-05	8.08E-05	8.08E-05	8.08E-05	8.08E-05	1.16E-04	1.49E-04
Co-60	1.70E+00	1.70E+00	1.70E+00	1.70E+00	1.70E+00	1.70E+00	1.70E+00	1.70E+00	1.70E+00	2.44E+00	3.14E+00
Cs-137	6.31E-03	6.31E-03	6.31E-03	6.31E-03	6.31E-03	6.31E-03	6.31E-03	6.31E-03	6.31E-03	9.09E-03	1.17E-02
H-3	1.16E-02	1.16E-02	1.16E-02	1.16E-02	1.16E-02	1.16E-02	1.16E-02	1.16E-02	1.16E-02	1.66E-02	2.14E-02
I-129	2.65E-03	2.65E-03	2.65E-03	2.65E-03	2.65E-03	2.65E-03	2.65E-03	2.65E-03	2.65E-03	3.82E-03	4.91E-03
Nb-94	8.92E-02	8.92E-02	8.92E-02	8.92E-02	8.92E-02	8.92E-02	8.92E-02	8.92E-02	8.92E-02	1.29E-01	1.65E-01
Ni-59	1.52E-03	1.52E-03	1.52E-03	1.52E-03	1.52E-03	1.52E-03	1.52E-03	1.52E-03	1.52E-03	2.19E-03	2.81E-03
Ni-63	4.64E-02	4.64E-02	4.64E-02	4.64E-02	4.64E-02	4.64E-02	4.64E-02	4.64E-02	4.64E-02	6.68E-02	8.57E-02
Pu-238	1.50E-05	1.50E-05	1.50E-05	1.50E-05	1.50E-05	1.50E-05	1.50E-05	1.50E-05	1.50E-05	2.16E-05	2.77E-05
Pu-239	3.59E-06	3.59E-06	3.59E-06	3.59E-06	3.59E-06	3.59E-06	3.59E-06	3.59E-06	3.59E-06	5.17E-06	6.63E-06
Pu-240	3.59E-06	3.59E-06	3.59E-06	3.59E-06	3.59E-06	3.59E-06	3.59E-06	3.59E-06	3.59E-06	5.17E-06	6.63E-06
Sr-90	1.94E-02	1.94E-02	1.94E-02	1.94E-02	1.94E-02	1.94E-02	1.94E-02	1.94E-02	1.94E-02	2.79E-02	3.58E-02
Tc-99	1.07E-01	1.07E-01	1.07E-01	1.07E-01	1.07E-01	1.07E-01	1.07E-01	1.07E-01	1.07E-01	1.54E-01	1.97E-01

Table A-9. (continued).

Waste Stream TRA-603-1N (1971-1981)											
Isotope	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Am-241	2.93E-05	7.32E-06	9.48E-06	1.24E-05	1.41E-05	1.41E-05	9.19E-06	1.25E-05	1.25E-05	9.37E-06	1.17E-05
C-14	2.13E-02	5.32E-03	6.89E-03	9.05E-03	1.03E-02	1.02E-02	6.68E-03	9.10E-03	9.06E-03	6.81E-03	8.51E-03
Cm-242	3.48E-05	8.67E-06	1.12E-05	1.48E-05	1.67E-05	1.67E-05	1.09E-05	1.48E-05	1.48E-05	1.11E-05	1.39E-05
Cm-244	1.58E-04	3.95E-05	5.11E-05	6.71E-05	7.62E-05	7.58E-05	4.96E-05	6.75E-05	6.72E-05	5.05E-05	6.31E-05
Co-60	3.32E+00	8.29E-01	1.07E+00	1.41E+00	1.60E+00	1.59E+00	1.04E+00	1.42E+00	1.41E+00	1.06E+00	1.33E+00
Cs-137	1.24E-02	3.08E-03	3.99E-03	5.24E-03	5.95E-03	5.92E-03	3.87E-03	5.27E-03	5.25E-03	3.95E-03	4.93E-03
H-3	2.26E-02	5.65E-03	7.31E-03	9.61E-03	1.09E-02	1.08E-02	7.09E-03	9.66E-03	9.61E-03	7.23E-03	9.03E-03
I-129	5.19E-03	1.30E-03	1.68E-03	2.21E-03	2.50E-03	2.49E-03	1.63E-03	2.22E-03	2.21E-03	1.66E-03	2.07E-03
Nb-94	1.75E-01	4.36E-02	5.65E-02	7.42E-02	8.42E-02	8.38E-02	5.48E-02	7.46E-02	7.42E-02	5.58E-02	6.97E-02
Ni-59	2.98E-03	7.43E-04	9.63E-04	1.26E-03	1.43E-03	1.43E-03	9.34E-04	1.27E-03	1.27E-03	9.52E-04	1.19E-03
Ni-63	9.08E-02	2.27E-02	2.93E-02	3.85E-02	4.37E-02	4.35E-02	2.85E-02	3.87E-02	3.86E-02	2.90E-02	3.62E-02
Pu-238	2.93E-05	7.32E-06	9.48E-06	1.24E-05	1.41E-05	1.41E-05	9.19E-06	1.25E-05	1.25E-05	9.37E-06	1.17E-05
Pu-239	7.02E-06	1.75E-06	2.27E-06	2.98E-06	3.38E-06	3.37E-06	2.20E-06	3.00E-06	2.98E-06	2.24E-06	2.80E-06
Pu-240	7.02E-06	1.75E-06	2.27E-06	2.98E-06	3.38E-06	3.37E-06	2.20E-06	3.00E-06	2.98E-06	2.24E-06	2.80E-06
Sr-90	3.79E-02	9.46E-03	1.23E-02	1.61E-02	1.83E-02	1.82E-02	1.19E-02	1.62E-02	1.61E-02	1.21E-02	1.51E-02
Tc-99	2.09E-01	5.21E-02	6.75E-02	8.87E-02	1.01E-01	1.00E-01	6.55E-02	8.92E-02	8.88E-02	6.68E-02	8.33E-02

Table A-9. (continued).

Waste Stream TRA-603-1N (1982-1993)												
Isotope	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Am-241	1.31E-05	1.47E-05	1.36E-05	1.38E-05	1.04E-05	1.53E-05	1.47E-05	1.01E-05	1.33E-05	1.12E-05	1.03E-05	6.18E-06
C-14	9.50E-03	1.07E-02	9.93E-03	1.00E-02	7.59E-03	1.11E-02	1.07E-02	7.37E-03	9.69E-03	8.13E-03	7.49E-03	4.49E-03
Cm-242	1.55E-05	1.75E-05	1.62E-05	1.63E-05	1.24E-05	1.81E-05	1.74E-05	1.20E-05	1.58E-05	1.33E-05	1.22E-05	7.33E-06
Cm-244	7.05E-05	7.95E-05	7.36E-05	7.42E-05	5.63E-05	8.25E-05	7.92E-05	5.47E-05	7.19E-05	6.03E-05	5.55E-05	3.33E-05
Co-60	1.48E+00	1.67E+00	1.55E+00	1.56E+00	1.18E+00	1.73E+00	1.66E+00	1.15E+00	1.51E+00	1.27E+00	1.17E+00	7.00E-01
Cs-137	5.50E-03	6.21E-03	5.75E-03	5.80E-03	4.40E-03	6.44E-03	6.19E-03	4.27E-03	5.62E-03	4.71E-03	4.34E-03	2.60E-03
H-3	1.01E-02	1.14E-02	1.05E-02	1.06E-02	8.06E-03	1.18E-02	1.13E-02	7.83E-03	1.03E-02	8.63E-03	7.94E-03	4.77E-03
I-129	2.31E-03	2.61E-03	2.42E-03	2.44E-03	1.85E-03	2.71E-03	2.60E-03	1.80E-03	2.36E-03	1.98E-03	1.82E-03	1.09E-03
Nb-94	7.79E-02	8.78E-02	8.13E-02	8.20E-02	6.22E-02	9.11E-02	8.75E-02	6.04E-02	7.94E-02	6.66E-02	6.14E-02	3.68E-02
Ni-59	1.33E-03	1.50E-03	1.39E-03	1.40E-03	1.06E-03	1.55E-03	1.49E-03	1.03E-03	1.35E-03	1.14E-03	1.05E-03	6.28E-04
Ni-63	4.05E-02	4.56E-02	4.23E-02	4.26E-02	3.23E-02	4.74E-02	4.55E-02	3.14E-02	4.13E-02	3.46E-02	3.19E-02	1.91E-02
Pu-238	1.31E-05	1.47E-05	1.36E-05	1.38E-05	1.04E-05	1.53E-05	1.47E-05	1.01E-05	1.33E-05	1.12E-05	1.03E-05	6.18E-06
Pu-239	3.13E-06	3.53E-06	3.27E-06	3.30E-06	2.50E-06	3.66E-06	3.52E-06	2.43E-06	3.19E-06	2.68E-06	2.47E-06	1.48E-06
Pu-240	3.13E-06	3.53E-06	3.27E-06	3.30E-06	2.50E-06	3.66E-06	3.52E-06	2.43E-06	3.19E-06	2.68E-06	2.47E-06	1.48E-06
Sr-90	1.69E-02	1.90E-02	1.76E-02	1.78E-02	1.35E-02	1.98E-02	1.90E-02	1.31E-02	1.72E-02	1.45E-02	1.33E-02	7.99E-03
Tc-99	9.31E-02	1.05E-01	9.73E-02	9.80E-02	7.44E-02	1.09E-01	1.05E-01	7.23E-02	9.50E-02	7.96E-02	7.34E-02	4.40E-02

Table A-9. (continued).

Waste Stream TRA-603-15N (1959-1968)										
Isotope	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Am-241	1.84E-04	1.34E-04	2.63E-04	2.32E-04	8.08E-07	1.13E-05	3.31E-04	9.24E-04	3.70E-06	1.01E-05
Am-243	5.13E-07	3.72E-07	7.31E-07	6.45E-07	2.25E-09	3.15E-08	9.22E-07	2.57E-06	1.03E-08	2.82E-08
Be-10	1.05E-07	1.23E-07	1.07E-07	1.06E-07	1.05E-09	4.59E-09	6.57E-08	3.75E-07	1.50E-09	4.75E-09
C-14	7.94E-02	9.29E-02	8.14E-02	8.05E-02	7.97E-04	3.47E-03	4.98E-02	2.84E-01	1.13E-03	3.60E-03
Ce-144	3.59E+01	2.60E+01	5.12E+01	4.52E+01	1.57E-01	2.21E+00	6.45E+01	1.80E+02	7.20E-01	1.97E+00
Cl-36	4.03E-10	4.72E-10	4.13E-10	4.08E-10	4.05E-12	1.76E-11	2.53E-10	1.44E-09	5.76E-12	1.83E-11
Cm-243	1.72E-07	1.24E-07	2.45E-07	2.16E-07	7.53E-10	1.05E-08	3.09E-07	8.61E-07	3.44E-09	9.44E-09
Cm-244	1.51E-05	1.09E-05	2.15E-05	1.90E-05	6.61E-08	9.26E-07	2.71E-05	7.56E-05	3.02E-07	8.29E-07
Co-60	1.31E+02	1.53E+02	1.34E+02	1.33E+02	1.32E+00	5.74E+00	8.22E+01	4.69E+02	1.87E+00	5.95E+00
Cs-134	5.52E+00	4.01E+00	7.87E+00	6.95E+00	2.42E-02	3.39E-01	9.93E+00	2.77E+01	1.11E-01	3.04E-01
Cs-137	1.77E+01	1.29E+01	2.53E+01	2.23E+01	7.79E-02	1.09E+00	3.19E+01	8.91E+01	3.56E-01	9.76E-01
Eu-152	5.74E-04	4.17E-04	8.19E-04	7.23E-04	2.52E-06	3.53E-05	1.03E-03	2.88E-03	1.15E-05	3.16E-05
Eu-154	5.20E-01	3.77E-01	7.42E-01	6.55E-01	2.28E-03	3.20E-02	9.36E-01	2.61E+00	1.04E-02	2.86E-02
H-3	6.97E-02	5.06E-02	9.94E-02	8.77E-02	3.06E-04	4.28E-03	1.25E-01	3.50E-01	1.40E-03	3.83E-03
I-129	4.22E-06	3.06E-06	6.02E-06	5.31E-06	1.85E-08	2.59E-07	7.59E-06	2.12E-05	8.47E-08	2.32E-07
Nb-94	1.93E-02	2.26E-02	1.98E-02	1.95E-02	1.94E-04	8.44E-04	1.21E-02	6.89E-02	2.76E-04	8.74E-04
Ni-59	1.42E-01	1.67E-01	1.46E-01	1.44E-01	1.43E-03	6.23E-03	8.92E-02	5.09E-01	2.03E-03	6.45E-03
Ni-63	2.91E+01	3.41E+01	2.98E+01	2.95E+01	2.92E-01	1.27E+00	1.83E+01	1.04E+02	4.16E-01	1.32E+00
Np-237	3.48E-05	2.52E-05	4.96E-05	4.38E-05	1.53E-07	2.14E-06	6.25E-05	1.74E-04	6.98E-07	1.91E-06
Pm-147	2.56E+01	1.86E+01	3.66E+01	3.23E+01	1.13E-01	1.58E+00	4.61E+01	1.29E+02	5.15E-01	1.41E+00
Pu-238	6.60E-02	4.79E-02	9.42E-02	8.31E-02	2.90E-04	4.06E-03	1.19E-01	3.31E-01	1.33E-03	3.63E-03

Table A-9. (continued).

Waste Stream TRA-603-15N (1959-1968)										
Isotope	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Pu-239	3.61E-04	2.62E-04	5.14E-04	4.54E-04	1.58E-06	2.22E-05	6.49E-04	1.81E-03	7.24E-06	1.98E-05
Pu-240	2.93E-04	2.12E-04	4.17E-04	3.68E-04	1.28E-06	1.80E-05	5.26E-04	1.47E-03	5.87E-06	1.61E-05
Pu-241	3.45E-02	2.50E-02	4.92E-02	4.34E-02	1.51E-04	2.12E-03	6.20E-02	1.73E-01	6.92E-04	1.90E-03
Pu-242	1.60E-07	1.16E-07	2.28E-07	2.01E-07	7.02E-10	9.84E-09	2.88E-07	8.03E-07	3.21E-09	8.81E-09
Ra-226	4.30E-14	3.12E-14	6.13E-14	5.41E-14	1.89E-16	2.64E-15	7.73E-14	2.16E-13	8.62E-16	2.36E-15
Ra-228	2.21E-15	1.61E-15	3.16E-15	2.79E-15	9.71E-18	1.36E-16	3.98E-15	1.11E-14	4.44E-17	1.22E-16
Sr-90	1.71E+01	1.24E+01	2.43E+01	2.15E+01	7.49E-02	1.05E+00	3.07E+01	8.56E+01	3.42E-01	9.39E-01
Tc-99	2.58E-03	1.87E-03	3.67E-03	3.24E-03	1.14E-05	1.58E-04	4.62E-03	1.29E-02	5.17E-05	1.42E-04
Th-228	9.35E-08	6.79E-08	1.33E-07	1.18E-07	4.10E-10	5.75E-09	1.68E-07	4.69E-07	1.88E-09	5.14E-09
Th-229	7.80E-13	5.66E-13	1.11E-12	9.81E-13	3.42E-15	4.79E-14	1.40E-12	3.91E-12	1.56E-14	4.29E-14
Th-230	6.37E-11	4.62E-11	9.08E-11	8.02E-11	2.80E-13	3.91E-12	1.15E-10	3.20E-10	1.28E-12	3.50E-12
Th-232	1.45E-14	1.05E-14	2.07E-14	1.83E-14	6.37E-17	8.92E-16	2.61E-14	7.29E-14	2.91E-16	7.99E-16
TRA-MFP	1.18E+01	8.58E+00	1.69E+01	1.49E+01	5.19E-02	7.27E-01	2.13E+01	5.93E+01	2.37E-01	6.51E-01
U-232	1.89E-07	1.37E-07	2.70E-07	2.38E-07	8.31E-10	1.16E-08	3.41E-07	9.50E-07	3.80E-09	1.04E-08
U-233	2.60E-09	1.89E-09	3.71E-09	3.28E-09	1.14E-11	1.60E-10	4.68E-09	1.31E-08	5.22E-11	1.43E-10
U-234	2.48E-06	1.80E-06	3.53E-06	3.12E-06	1.09E-08	1.52E-07	4.46E-06	1.24E-05	4.97E-08	1.36E-07
U-235	2.36E-05	1.71E-05	3.36E-05	2.97E-05	1.04E-07	1.45E-06	4.24E-05	1.18E-04	4.73E-07	6.73E-05
U-236	8.97E-05	6.51E-05	1.28E-04	1.13E-04	3.94E-07	5.51E-06	1.61E-04	4.50E-04	1.80E-06	4.93E-06
U-238	4.28E-07	3.11E-07	6.10E-07	5.39E-07	1.88E-09	2.63E-08	7.70E-07	2.15E-06	8.59E-09	2.35E-08
TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.										

Table A-9. (continued).

Waste Stream TRA-603-15N (1969-1977)									
Isotope	1969	1970	1971	1972	1973	1974	1975	1976	1977
Am-241	5.17E-05	7.59E-06	1.27E-06	1.17E-05	3.60E-07	2.16E-06	6.12E-08	5.31E-05	2.17E-06
Am-243	1.44E-07	2.11E-08	3.54E-09	3.26E-08	1.00E-09	6.02E-09	1.70E-10	1.48E-07	6.04E-09
Be-10	2.77E-06	3.08E-09	5.16E-10	4.75E-09	1.46E-10	8.77E-10	2.48E-11	2.15E-08	8.79E-10
C-14	4.25E-01	2.33E-03	3.91E-04	3.60E-03	1.11E-04	6.64E-04	1.88E-05	1.63E-02	6.66E-04
Ce-144	1.01E+01	1.48E+00	2.48E-01	2.28E+00	7.02E-02	4.22E-01	1.19E-02	1.04E+01	4.23E-01
Cl-36	6.58E-08	1.18E-11	1.98E-12	1.82E-11	5.61E-13	3.37E-12	9.53E-14	8.28E-11	3.38E-12
Cm-243	4.82E-08	7.07E-09	1.19E-09	1.09E-08	3.36E-10	2.01E-09	5.70E-11	4.95E-08	2.02E-09
Cm-244	4.23E-06	6.21E-07	1.04E-07	9.58E-07	2.95E-08	1.77E-07	5.00E-09	4.35E-06	1.78E-07
Co-60	3.21E+03	3.85E+00	6.45E-01	5.94E+00	1.83E-01	1.10E+00	3.10E-02	2.69E+01	1.10E+00
Cs-134	1.55E+00	2.28E-01	3.81E-02	3.51E-01	1.08E-02	6.49E-02	1.83E-03	1.59E+00	6.51E-02
Cs-137	4.98E+00	7.31E-01	1.23E-01	1.13E+00	3.47E-02	2.08E-01	5.89E-03	5.12E+00	2.09E-01
Eu-152	1.61E-04	2.37E-05	3.97E-06	3.65E-05	1.12E-06	6.74E-06	1.91E-07	1.66E-04	6.77E-06
Eu-154	1.46E-01	2.14E-02	3.59E-03	3.31E-02	1.02E-03	6.11E-03	1.73E-04	1.50E-01	6.13E-03
H-3	1.96E-02	2.87E-03	4.81E-04	4.43E-03	1.36E-04	8.19E-04	2.31E-05	2.01E-02	8.21E-04
I-129	1.18E-06	1.74E-07	2.92E-08	2.68E-07	8.25E-09	4.96E-08	1.40E-09	1.22E-06	4.97E-08
Nb-94	1.91E-02	5.66E-04	9.49E-05	8.73E-04	2.69E-05	1.61E-04	4.56E-06	3.96E-03	1.62E-04
Ni-59	1.92E+00	4.18E-03	7.00E-04	6.44E-03	1.98E-04	1.19E-03	3.37E-05	2.92E-02	1.19E-03
Ni-63	2.90E+02	8.54E-01	1.43E-01	1.32E+00	4.05E-02	2.43E-01	6.88E-03	5.98E+00	2.44E-01
Np-237	9.76E-06	1.43E-06	2.40E-07	2.21E-06	6.80E-08	4.08E-07	1.15E-08	1.00E-05	4.10E-07
Pm-147	7.20E+00	1.06E+00	1.77E-01	1.63E+00	5.01E-02	3.01E-01	8.52E-03	7.40E+00	3.02E-01
Pu-238	1.85E-02	2.72E-03	4.56E-04	4.20E-03	1.29E-04	7.76E-04	2.19E-05	1.91E-02	7.78E-04

Table A-9. (continued).

Waste Stream TRA-603-15N (1969-1977)									
Isotope	1969	1970	1971	1972	1973	1974	1975	1976	1977
Pu-239	1.01E-04	1.49E-05	2.49E-06	2.29E-05	7.06E-07	4.24E-06	1.20E-07	1.04E-04	4.25E-06
Pu-240	8.22E-05	1.21E-05	2.02E-06	1.86E-05	5.72E-07	3.44E-06	9.72E-08	8.44E-05	3.45E-06
Pu-241	9.68E-03	1.42E-03	2.38E-04	2.19E-03	6.75E-05	4.05E-04	1.15E-05	9.95E-03	4.06E-04
Pu-242	4.49E-08	6.60E-09	1.11E-09	1.02E-08	3.13E-10	1.88E-09	5.32E-11	4.62E-08	1.89E-09
Ra-226	1.21E-14	1.77E-15	2.97E-16	2.73E-15	8.40E-17	5.05E-16	1.43E-17	1.24E-14	5.06E-16
Ra-228	6.21E-16	9.12E-17	1.53E-17	1.41E-16	4.33E-18	2.60E-17	7.35E-19	6.39E-16	2.61E-17
Sr-90	4.79E+00	7.03E-01	1.18E-01	1.09E+00	3.34E-02	2.00E-01	5.67E-03	4.92E+00	2.01E-01
Tc-99	8.12E-04	1.06E-04	1.78E-05	1.64E-04	5.04E-06	3.02E-05	8.55E-07	7.43E-04	3.03E-05
Th-228	2.62E-08	3.85E-09	6.46E-10	5.95E-09	1.83E-10	1.10E-09	3.11E-11	2.70E-08	1.10E-09
Th-229	2.19E-13	3.21E-14	5.39E-15	4.96E-14	1.53E-15	9.16E-15	2.59E-16	2.25E-13	9.19E-15
Th-230	1.79E-11	2.62E-12	4.40E-13	4.05E-12	1.25E-13	7.48E-13	2.12E-14	1.84E-11	7.50E-13
Th-232	4.08E-15	5.98E-16	1.00E-16	9.23E-16	2.84E-17	1.71E-16	4.82E-18	4.19E-15	1.71E-16
TRA-MFP	3.32E+00	4.87E-01	8.17E-02	7.52E-01	2.31E-02	1.39E-01	3.93E-03	3.41E+00	1.39E-01
U-232	5.31E-08	7.80E-09	1.31E-09	1.20E-08	3.70E-10	2.22E-09	6.29E-11	5.46E-08	2.23E-09
U-233	7.31E-10	1.07E-10	1.80E-11	1.66E-10	5.09E-12	3.06E-11	8.65E-13	7.51E-10	3.07E-11
U-234	6.96E-07	1.02E-07	1.71E-08	1.58E-07	4.85E-09	2.91E-08	8.23E-10	7.15E-07	2.92E-08
U-235	6.62E-06	9.72E-07	1.63E-07	1.50E-06	4.61E-08	2.77E-07	7.84E-09	6.81E-06	2.78E-07
U-236	2.52E-05	3.70E-06	6.20E-07	5.70E-06	1.75E-07	1.05E-06	2.98E-08	2.59E-05	1.06E-06
U-238	1.20E-07	1.76E-08	2.96E-09	2.72E-08	8.37E-10	5.03E-09	1.42E-10	1.23E-07	5.04E-09
TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.									

Table A-9. (continued).

Waste Stream TRA-603-15N (1981-1993)									
Isotope	1981	1983	1984	1985	1987	1988	1991	1992	1993
Am-241	4.03E-06	7.21E-05	1.61E-07	1.17E-07	7.01E-06	2.27E-06	4.39E-05	5.54E-08	3.82E-12
Am-243	1.12E-08	2.01E-07	4.48E-10	3.25E-10	1.95E-08	6.33E-09	1.22E-07	1.54E-10	1.06E-14
Be-10	1.63E-09	2.92E-08	6.53E-11	4.73E-11	8.85E-09	2.02E-09	1.78E-08	2.24E-11	1.55E-15
C-14	1.24E-03	2.21E-02	4.94E-05	3.59E-05	6.71E-03	1.53E-03	1.35E-02	1.70E-05	1.17E-09
Ce-144	7.84E-01	1.41E+01	3.14E-02	2.28E-02	1.37E+00	4.43E-01	8.55E+00	1.08E-02	7.45E-07
Cl-36	6.27E-12	1.12E-10	2.51E-13	1.82E-13	3.40E-11	7.77E-12	6.83E-11	8.63E-14	5.96E-18
Cm-243	3.75E-09	6.72E-08	1.50E-10	1.09E-10	6.53E-09	2.12E-09	4.09E-08	5.16E-11	3.56E-15
Cm-244	3.29E-07	5.90E-06	1.32E-08	9.56E-09	5.74E-07	1.86E-07	3.59E-06	4.53E-09	3.13E-13
Co-60	2.04E+00	3.66E+01	8.16E-02	5.92E-02	1.11E+01	2.53E+00	2.22E+01	2.81E-02	1.94E-06
Cs-134	1.21E-01	2.16E+00	4.83E-03	3.50E-03	2.10E-01	6.82E-02	1.32E+00	1.66E-03	1.15E-07
Cs-137	3.88E-01	6.95E+00	1.55E-02	1.13E-02	6.76E-01	2.19E-01	4.23E+00	5.34E-03	3.68E-07
Eu-152	1.25E-05	2.25E-04	5.02E-07	3.64E-07	2.19E-05	7.09E-06	1.37E-04	1.73E-07	1.19E-11
Eu-154	1.14E-02	2.04E-01	4.55E-04	3.30E-04	1.98E-02	6.42E-03	1.24E-01	1.56E-04	1.08E-08
H-3	1.52E-03	2.73E-02	6.09E-05	4.42E-05	2.65E-03	8.61E-04	1.66E-02	2.10E-05	1.45E-09
I-129	9.22E-08	1.65E-06	3.69E-09	2.68E-09	1.61E-07	5.21E-08	1.01E-06	1.27E-09	8.76E-14
Nb-94	3.00E-04	5.38E-03	1.20E-05	8.71E-06	1.63E-03	3.72E-04	3.27E-03	4.13E-06	2.85E-10
Ni-59	2.21E-03	3.97E-02	8.86E-05	6.43E-05	1.20E-02	2.75E-03	2.41E-02	3.05E-05	2.10E-09
Ni-63	4.53E-01	8.12E+00	1.81E-02	1.31E-02	2.46E+00	5.62E-01	4.94E+00	6.23E-03	4.30E-07
Np-237	7.60E-07	1.36E-05	3.04E-08	2.21E-08	1.32E-06	4.29E-07	8.28E-06	1.05E-08	7.22E-13
Pm-147	5.60E-01	1.00E+01	2.24E-02	1.63E-02	9.76E-01	3.17E-01	6.11E+00	7.71E-03	5.32E-07
Pu-238	1.44E-03	2.59E-02	5.77E-05	4.19E-05	2.51E-03	8.15E-04	1.57E-02	1.99E-05	1.37E-09

Table A-9. (continued).

Waste Stream TRA-603-15N (1981-1993)									
Isotope	1981	1983	1984	1985	1987	1988	1991	1992	1993
Pu-239	7.89E-06	1.41E-04	3.15E-07	2.29E-07	1.37E-05	4.45E-06	8.59E-05	1.08E-07	7.49E-12
Pu-240	6.40E-06	1.15E-04	2.56E-07	1.86E-07	1.11E-05	3.61E-06	6.97E-05	8.80E-08	6.08E-12
Pu-241	7.54E-04	1.35E-02	3.02E-05	2.19E-05	1.31E-03	4.26E-04	8.22E-03	1.04E-05	7.16E-10
Pu-242	3.50E-09	6.27E-08	1.40E-10	1.02E-10	6.09E-09	1.98E-09	3.81E-08	4.81E-11	3.32E-15
Ra-226	9.39E-16	1.68E-14	3.76E-17	2.72E-17	1.64E-15	5.30E-16	1.02E-14	1.29E-17	8.92E-22
Ra-228	4.84E-17	8.67E-16	1.93E-18	1.40E-18	8.43E-17	2.73E-17	5.27E-16	6.66E-19	4.60E-23
Sr-90	3.73E-01	6.68E+00	1.49E-02	1.08E-02	6.50E-01	2.11E-01	4.06E+00	5.13E-03	3.54E-07
Tc-99	5.63E-05	1.01E-03	2.25E-06	1.63E-06	9.85E-05	3.19E-05	6.13E-04	7.74E-07	5.35E-11
Th-228	2.04E-09	3.66E-08	8.18E-11	5.93E-11	3.56E-09	1.15E-09	2.23E-08	2.81E-11	1.94E-15
Th-229	1.70E-14	3.05E-13	6.82E-16	4.95E-16	2.97E-14	9.63E-15	1.86E-13	2.34E-16	1.62E-20
Th-230	1.39E-12	2.49E-11	5.57E-14	4.04E-14	2.42E-12	7.86E-13	1.52E-11	1.92E-14	1.32E-18
Th-232	3.17E-16	5.68E-15	1.27E-17	9.21E-18	5.53E-16	1.79E-16	3.46E-15	4.37E-18	3.01E-22
TRA-MFP	2.58E-01	4.63E+00	1.03E-02	7.50E-03	4.50E-01	1.46E-01	2.82E+00	3.56E-03	2.46E-07
U-232	4.14E-09	7.41E-08	1.66E-10	1.20E-10	7.21E-09	2.34E-09	4.51E-08	5.69E-11	3.93E-15
U-233	5.69E-11	1.02E-09	2.28E-12	1.65E-12	9.91E-11	3.21E-11	6.20E-10	7.83E-13	5.41E-17
U-234	5.42E-08	9.70E-07	2.17E-09	1.57E-09	9.43E-08	3.06E-08	5.90E-07	7.45E-10	5.15E-14
U-235	5.16E-07	9.24E-06	2.06E-08	1.50E-08	8.98E-07	2.91E-07	5.62E-06	7.10E-09	4.90E-13
U-236	1.96E-06	3.51E-05	7.84E-08	5.69E-08	3.41E-06	1.11E-06	2.14E-05	2.70E-08	1.86E-12
U-238	9.35E-09	1.68E-07	3.74E-10	2.71E-10	1.63E-08	5.28E-09	1.02E-07	1.29E-10	8.89E-15
TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.									

Table A-9. (continued).

Waste Stream TRA-603-13N				
Isotope	1960	1961	1971	1973
Am-241	8.86E-06	1.61E-04	8.05E-10	1.66E-05
Am-243	2.46E-08	4.48E-07	2.24E-12	4.63E-08
Be-10	3.59E-09	6.53E-08	3.26E-13	6.74E-09
C-14	2.72E-03	4.94E-02	2.47E-07	5.11E-03
Ce-144	1.73E+00	3.14E+01	1.57E-04	3.24E+00
Cl-36	1.38E-11	2.51E-10	1.25E-15	2.59E-11
Cm-243	8.25E-09	1.50E-07	7.50E-13	1.55E-08
Cm-244	7.25E-07	1.32E-05	6.59E-11	1.36E-06
Co-60	4.49E+00	8.16E+01	4.08E-04	8.43E+00
Cs-134	2.66E-01	4.83E+00	2.41E-05	4.99E-01
Cs-137	8.53E-01	1.55E+01	7.76E-05	1.60E+00
Eu-152	2.76E-05	5.02E-04	2.51E-09	5.19E-05
Eu-154	2.50E-02	4.55E-01	2.27E-06	4.70E-02
H-3	3.35E-03	6.09E-02	3.05E-07	6.29E-03
I-129	2.03E-07	3.69E-06	1.84E-11	3.81E-07
Nb-94	6.60E-04	1.20E-02	6.00E-08	1.24E-03
Ni-59	4.87E-03	8.86E-02	4.43E-07	9.15E-03
Ni-63	9.97E-01	1.81E+01	9.06E-05	1.87E+00
Np-237	1.67E-06	3.04E-05	1.52E-10	3.14E-06
Pm-147	1.23E+00	2.24E+01	1.12E-04	2.32E+00
Pu-238	3.18E-03	5.77E-02	2.89E-07	5.96E-03
Pu-239	1.73E-05	3.15E-04	1.58E-09	3.26E-05
Pu-240	1.41E-05	2.56E-04	1.28E-09	2.64E-05
Pu-241	1.66E-03	3.02E-02	1.51E-07	3.12E-03
Pu-242	7.70E-09	1.40E-07	7.00E-13	1.45E-08
Ra-226	2.07E-15	3.76E-14	1.88E-19	3.88E-15
Ra-228	1.06E-16	1.93E-15	9.67E-21	2.00E-16
Sr-90	8.21E-01	1.49E+01	7.46E-05	1.54E+00
Tc-99	1.24E-04	2.25E-03	1.13E-08	2.32E-04
Th-228	4.50E-09	8.18E-08	4.09E-13	8.45E-09
Th-229	3.75E-14	6.82E-13	3.41E-18	7.04E-14

Table A-9. (continued).

Waste Stream TRA-603-13N				
Isotope	1960	1961	1971	1973
Th-230	3.06E-12	5.57E-11	2.78E-16	5.75E-12
Th-232	6.98E-16	1.27E-14	6.35E-20	1.31E-15
TRA-MFP	5.69E-01	1.03E+01	5.17E-05	1.07E+00
U-232	9.10E-09	1.66E-07	8.28E-13	1.71E-08
U-233	1.25E-10	2.28E-09	1.14E-14	2.35E-10
U-234	1.19E-07	2.17E-06	1.08E-11	2.24E-07
U-235	1.13E-06	2.06E-05	1.03E-10	2.13E-06
U-236	4.31E-06	7.84E-05	3.92E-10	8.10E-06
U-238	2.06E-08	3.74E-07	1.87E-12	3.87E-08
TRA-MFP = Nuclides that combined make up 10% of the total, but individually are less than a tenth percent each.				

A-11. REFERENCES

Croff, A. G., 1980, ORIGEN2—*A Revised and Updated Version of the Oak Ridge Isotope Generation and Depletion Code*, ORNL-5621, Oak Ridge National Laboratory Report, Oak Ridge, Tennessee.

Logan, J., 1999, *Assessment of Neutron-Activation Products in Low Level Waste Discharged From Nuclear Reactors at the Test Reactor Area and Sent to the Radioactive Waste Management Complex for Disposal*, INEEL/MISC-03-00362, Idaho National Engineering and Environmental Laboratory.

Mullen, Carlen K., Glen R. Longhurst, Michael L. Carboneau, and James W. Sterbentz, 2003, *Beryllium Waste Transuranic Inventory in the Subsurface Disposal Area Operable Unit 7-13/14,* INEEL/EXT-01-01678, Rev. 2, Idaho National Engineering and Environmental Laboratory.

Electric Power Research Institute (EPRI), *Updated Scaling Factors in Low-Level Radwaste*, EPRI NP-5077 Final Report, March 1987.

Appendix B

Summary of Radiological and Chemical Inventory and Refinements

CONTENTS

TABLES

ACRONYMS

ANL-W	Argonne National Laboratory-West (now called Materials and Fuels Complex)
HDT	Historical Data Task
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
MFC	Materials and Fuels Complex (formerly Argonne National Laboratory-West)
NRF	Naval Reactors Facility
ORIGEN2	Oak Ridge Isotope GENeration and Depletion Code Version 2
RFP	Rocky Flats Plant
RI/FS	remedial investigation and feasibility study
RPDT	Recent and Projected Data Task
RTC	Reactor Technology Complex (formerly Test Reactor Area)
TAN	Test Area North
TRA	Test Reactor Area (now called Reactor Technology Complex)
TSA	Transuranic Storage Area
WILD	Waste Information and Location Database

Appendix B

Summary of Radiological and Chemical Inventory and Refinements

A data set was taken from the Waste Information and Location Database (WILD) on November 29, 2004, to serve as the source term inventory for the OU 7-13/14 RI/BRA and FS. This particular data set is referred to as the remedial investigation and feasibility study (RI/FS) Snapshot[a]. Tables in the sections that follow record the development of the RI/FS Snapshot. Subsequent modifications to the source term inventory applied to the Snapshot and used in the RI/FS will be documented in the RI/BRA report.

B-1. TEST AREA NORTH

The Historical Data Task (HDT) and Recent and Projected Data Task (RPDT) isotope values were updated based on evaluation by Studley et al. (2004) of waste disposal data from Test Area North (TAN) and the use of Oak Ridge Isotope GENeration and Depletion Code Version 2 (ORIGEN2) models. Data from Studley et al. were partitioned (see Section 4 of this report) to individual shipments for input in WILD. During partitioning, additional TAN waste shipments were identified. Methods used by Studley et al. were applied to these additional shipments and resulted in an increase in isotope values for TAN from the values in Studley et al. Isotope values in the Snapshot for the RI/FS are the sum of values from Appendix C of this report and the RPDT Supplement (Little et al. 2001). These values are shown in Table B-1.

a. The RI/FS Snapshot is the sum of values from the Waste Information and Location Database and Little et al. (2001).

Table B-1. Test Area North (TAN) nuclide values (curies).

Selected Isotopes[a]	HDT and RPDT[b]	Carboneau and Vail 1951-1993	1951–1993 [c] (See App. C this report)	RPDT Supplement 1994–2000	RI/FS Snapshot[d]
Ac-227	No data	6.95E-07	6.74E-07	No data	6.74E-07
Am-241	7.14E-02	9.58E-01	1.07E+00	2.35E-01	1.30E+00
Am-243	No data	5.62E-04	7.59E-04	No data	7.59E-04
C-14	5.97E-01	4.98E-07	1.32E-04	1.57E-03	1.70E-03
Cl-36	No data	9.15E-03	1.06E-02	2.00E-08	1.06E-02
Cm-244	2.26E-03	8.86E-03	1.23E-02	3.29E-03	1.56E-02
Co-60	1.81E+04	9.53E+03	1.19E+04	1.60E+02	1.20E+04
Cs-137	7.37E+03	4.57E+03	4.70E+03	9.63E+00	4.71E+03
Eu-152	4.76E-06	1.12E-01	1.35E-01	1.23E-02	1.47E-01
Eu-154	3.71E-01	2.02E+01	2.59E+01	3.84E-02	2.59E+01
H-3	4.57E+01	1.82E+01	1.93E+01	8.72E+01	1.06E+02
I-129	5.37E-04	1.17E-03	1.20E-03	6.07E-05	1.26E-03
Na-22	No data	No data	No data	1.01E-06	1.01E-06
Nb-94	1.64E-02	5.56E-05	7.52E-05	1.31E-02	1.32E-02
Ni-59	6.17E+03	6.83E+00	7.51E+00	2.71E-01	7.78E+00
Ni-63	6.45E+02	9.10E+02	1.00E+03	2.43E+01	1.03E+03
Np-237	1.21E-07	2.42E-03	2.90E-03	No data	2.90E-03
Pa-231	No data	1.18E-05	1.08E-05	No data	1.08E-05
Pb-210	No data	5.85E-09	5.84E-09	No data	5.84E-09
Pu-238	4.20E+00	1.92E+00	2.51E+00	3.82E-02	2.55E+00
Pu-239	8.21E-02	1.22E+01	1.45E+01	2.89E-02	1.45E+01
Pu-240	2.57E-04	2.97E+00	3.79E+00	3.99E-02	3.83E+00
Pu-241	1.46E-02	1.44E+02	1.97E+02	5.54E-02	1.97E+02
Pu-242	2.45E-08	3.20E-04	4.31E-04	No data	4.31E-04
Ra-226	1.00E+00	1.27E-07	1.22E-07	5.05E-03	5.05E-03
Sr-90	2.42E+03	4.32E+03	4.42E+03	2.00E+01	4.44E+03
Tc-99	5.53E-03	7.07E-01	7.15E-01	4.19E-03	7.20E-01
Th-228	No data	1.06E-04	1.05E-04	7.55E-03	7.66E-03
Th-229	No data	8.32E-10	8.58E-10	No data	8.58E-10
Th-230	No data	1.48E-04	1.37E-04	2.36E-03	2.50E-03
Th-232	No data	No data	No data	1.60E-02	1.60E-02
U-232	No data	1.44E-04	1.58E-04	4.72E-03	4.88E-03
U-233	No data	2.21E-06	2.28E-06	3.50E-01	3.50E-01
U-234	4.48E-01	4.66E+00	4.18E+00	2.40E+00	6.58E+00
U-235	1.25E-01	1.57E-01	1.40E-01	8.33E-02	2.23E-01
U-236	1.65E-06	3.27E-02	2.28E-02	5.10E-02	7.38E-02
U-238	9.79E-01	4.17E-02	5.23E-02	3.49E+00	3.54E+00

a. Isotopes are a list of selected contaminants of concern.

b. Changes from HDT and RPDT values to Studley et al. (2004) values occurred when engineering models were applied to TAN facility waste information. Models reported additional isotopes and did not report all isotopes addressed in HDT and RPDT.

c. Studley et al. (2004) analysis of TAN waste streams did not cover all shipments. The refinement of Studley et al. applied models to all waste shipments for the TAN facility.

d. The RI/FS Snapshot is the sum of values from the Waste Information and Location Database and RPDT Supplement (Little et al. 2001).

B-2. REACTOR TECHNOLOGY COMPLEX

The HDT and RPDT isotope values were updated based on the WILD evaluation of waste disposal data from the Reactor Technology Complex (RTC; formerly Test Reactor Area) and the use of ORIGEN2 models. Refined data from RTC were partitioned (see Appendix A of this report) to individual shipments for input in WILD. Logan's (1999) methods were applied to RTC shipments and resulted in an increase in isotope values for RTC from the values in HDT and RPDT. Isotope values in the RI/FS Snapshot are the sum of values from Appendix C of this report and the RPDT Supplement (Little et al. 2001). These values are shown in Table B-2.

Table B-2. Reactor Technology Complex (RTC; formerly Test Reactor Area) nuclide values (curies).

Selected Isotopes[a]	HDT and RPDT[b]	1951–1993[c] (See App. C this report)	RPDT Supplement 1994–2000	RI/FS Snapshot[d]
Ac-227	No data	7.19E-07	No data	7.19E-07
Am-241	1.33E+03	1.08E+00	1.35E+00	2.43E+00
Am-243	2.92E-01	7.13E-02	No data	7.13E-02
C-14	2.46E+04	5.30E+02	2.02E+00	5.32E+02
Cl-36	No data	8.87E-01	2.95E-06	8.87E-01
Cm-244	1.17E+02	4.40E+01	4.25E-02	4.41E+01
Co-60	1.75E+06	9.90E+05	1.01E+03	9.91E+05
Cs-137	5.20E+05	3.48E+04	1.18E+01	3.48E+04
Eu-152	1.07E+00	1.73E+00	1.94E+01	2.11E+01
Eu-154	3.89E+03	1.08E+03	3.20E+01	1.11E+03
H-3	1.51E+06	2.66E+06	4.17E+03	2.67E+06
I-129	1.24E-01	9.21E-02	6.85E-04	9.28E-02
Nb-94	2.04E-01	9.36E+01	3.36E-01	9.39E+01
Ni-59	2.22E+03	7.52E+02	1.58E+00	7.54E+02
Ni-63	7.76E+05	1.56E+05	1.72E+02	1.56E+05
Np-237	3.56E+00	6.79E-02	8.49E-04	6.88E-02
Pa-231	No data	2.58E-06	No data	2.58E-06
Pb-210	No data	1.06E-09	No data	1.06E-09
Pu-238	7.07E+02	1.30E+02	5.89E-02	1.30E+02
Pu-239	1.25E+02	4.38E+00	1.50E-02	4.40E+00
Pu-240	4.17E+01	8.15E-01	8.16E-03	8.24E-01
Pu-241	1.76E+04	1.48E+02	4.90E+00	1.53E+02
Pu-242	1.35E-02	5.80E-03	No data	5.80E-03
Ra-226	2.50E+00	2.26E-10	No data	2.26E-10
Ra-228	No data	1.49E-07	No data	1.49E-07
Sr-90	1.11E+05	3.34E+04	3.67E+00	3.34E+04
Tc-99	3.68E+02	8.45E+00	3.32E-03	8.45E+00
Th-228	No data	1.45E-03	1.13E-07	1.45E-03
Th-229	No data	5.84E-07	No data	5.84E-07
Th-230	No data	1.59E-07	5.20E-06	5.36E-06
Th-232	2.04E-02	2.10E+00	8.17E-03	2.11E+00
U-232	8.36E+00	8.36E+00	No data	8.36E+00
U-233	9.47E-03	6.01E-01	1.24E-07	6.01E-01
U-234	5.75E+00	8.19E-02	1.40E-03	8.33E-02
U-235	1.83E+00	5.29E-01	3.15E-05	5.29E-01
U-236	2.23E+00	1.75E-01	5.23E-04	1.76E-01
U-238	1.26E+00	4.47E-02	7.07E-05	4.47E-02

a. Isotopes are a list of selected contaminants of concern.

b. Changes from HDT and RPDT values to Waste Information and Location Database values occurred when engineering models were applied to facility information on waste produced. Models reported additional isotopes and did not report all isotopes addressed in HDT and RPDT.

c. The Waste Information and Location Database was the first refinement of data for the RTC facility.

d. The RI/FS Snapshot is the sum of values from the Waste Information and Location Database and RPDT Supplement (Little et al. 2001).

B-3. IDAHO NUCLEAR TECHNOLOGY AND ENGINEERING CENTER

The HDT and RPDT isotope values were updated based on evaluating the waste disposal data by Vail, Carboneau, and Longhurst (2004) and the use of ORIGEN2 models. Data from Vail, Carboneau, and Longhurst were partitioned (see Section 4 of this report) to individual shipments for input in WILD. During partitioning, additional waste shipments from the Idaho Nuclear Technology and Engineering Center (INTEC) were identified. Methods used by Vail, Carboneau, and Longhurst were applied to these additional shipments and resulted in an increase in isotope values for INTEC from the values shown by Vail, Carboneau, and Longhurst. Isotope values in the RI/FS Snapshot are the sum of values from Appendix C of this report and the RPDT Supplement (Little et al. 2001). These values are shown in Table B-3.

Table B-3. Idaho Nuclear Technology and Engineering Center (INTEC) nuclide values (curies).

Selected Isotopes[a]	HDT and RPDT[b]	Carboneau and Vail 1951-1993	1951–1993[c] (See App. C this report)	RPDT Supplement 1994–2000	RI/FS Snapshot[d]
Ac-227	No data	1.40E-06	1.90E-06	No data	1.90E-06
Am-241	No data	3.10E+00	4.95E+00	5.664E-02	5.00E+00
Am-243	No data	2.10E-02	4.34E-02	No data	4.34E-02
C-14	4.33E+01	2.60E+00	2.57E+00	2.852E-04	2.57E+00
Cl-36	No data	1.40E-03	1.41E-03	No data	1.41E-03
Cm-244	No data	5.70E-02	8.39E-02	1.201E-02	9.59E-02
Co-60	2.00E+05	1.60E+05	1.66E+05	1.732E-01	1.66E+05
Cs-137	4.26E+04	6.10E+04	6.70E+04	2.262E+01	6.71E+04
Eu-152	2.42E+02	1.40E+00	1.71E+00	4.890E+00	6.60E+00
Eu-154	2.91E+02	2.80E+02	3.06E+02	2.868E+00	3.09E+02
H-3	No data	3.80E+02	3.99E+02	2.561E-02	3.99E+02
I-129	No data	2.30E-02	2.45E-02	2.479E-05	2.45E-02
Nb-94	4.74E+01	5.90E-01	5.87E-01	No data	5.87E-01
Ni-59	1.62E+02	1.10E+01	1.14E+01	1.491E-04	1.14E+01
Ni-63	2.46E+04	8.50E+02	8.46E+02	1.058E-01	8.46E+02
Np-237	No data	4.30E-03	6.31E-03	5.735E-04	6.88E-03
Pa-231	No data	8.70E-06	9.08E-06	No data	9.08E-06
Pb-210	No data	2.90E-08	4.26E-08	No data	4.26E-08
Pu-238	1.01E+01	4.60E+01	7.06E+01	1.417E-02	7.06E+01
Pu-239	4.77E-01	5.80E+00	6.17E+00	2.593E-02	6.19E+00
Pu-240	1.00E-02	6.10E-01	9.26E-01	2.752E-03	9.29E-01
Pu-241	1.50E+01	7.50E+01	1.03E+02	2.826E+00	1.05E+02
Pu-242	1.00E-01	1.20E-03	1.86E-03	No data	1.86E-03
Ra-226	No data	3.60E-06	1.73E-04	2.177E-06	1.75E-04
Ra-228	No data	1.40E-09	8.71E-10	No data	8.71E-10
Sr-90	1.99E+04	5.80E+04	6.32E+04	1.049E+01	6.32E+04
Tc-99	3.03E-02	9.70E+00	1.10E+01	2.001E-02	1.10E+01
Th-228	No data	1.80E-01	2.66E-01	2.833E-06	2.66E-01
Th-229	No data	1.50E-08	1.91E-08	4.008E-06	4.03E-06
Th-230	No data	7.90E-05	8.61E-05	9.460E-06	9.55E-05
Th-232	No data	1.10E-02	1.15E-02	1.240E-05	1.15E-02
U-232	No data	6.80E-04	8.88E-04	No data	8.88E-04
U-233	No data	1.30E-05	1.37E-05	2.024E-04	2.16E-04
U-234	4.83E+01	2.40E+00	2.40E+00	3.515E-02	2.44E+00
U-235	1.56E-01	8.10E-02	1.01E+00	1.878E-03	1.02E+00
U-236	4.00E-03	1.30E-02	7.31E-02	5.274E-04	7.36E-02
U-238	6.61E-01	3.40E-01	3.40E-01	5.655E-04	3.40E-01

a. Isotopes are a list of selected contaminants of concern.

b. Changes from HDT and RPDT values to Carboneau and Vail (2004) values occurred when engineering models were applied to facility information on waste produced. Models reported additional isotopes and did not report all isotopes addressed in HDT and RPDT.

c. Additional waste shipment data were available when the INTEC data were refined; this increased the isotope values for all waste types.

d. The RI/FS Snapshot is the sum of values from the Waste Information and Location Database and RPDT Supplement (Little et al. 2001).

B-4. NAVAL REACTORS FACILITY

The HDT and RPDT isotope values for NRF were updated by the Naval Reactors: Idaho Branch Office (Dixon 2004a, Dixon 2004b), except for the values for Cm-244, Eu-152, and Eu-154; these values were updated by Little et al. (2001). The RI/FS Snapshot data for NRF are traced to preliminary estimates provided in Dixon (2004a) for waste streams NRF-MOD-1H through NRF-MOD-9H. Dixon (2004b) corrected a typographical error from Dixon (2004a) for Tc-99 in waste streams NRF-MOD-1H and NRF-MOD-2H. The data for NRF-MOD-10H and NRF-MOD-10R are based on analysis by DOE Idaho, Naval Reactors: Idaho Branch Office, and respective contract staff. This analysis received concurrence from Naval Reactors: Idaho Branch Office in Dixon (2004b). Values used in the RI/FS Snapshot are provided in Table B-4. Dixon (2005) provides the final inventory from NRF and Giles et al. (2005) provides the supplement to NRF's final report. The data provided replaced isotope values identified in the HDT and RPDT.

Table B-4. Naval Reactors Facility (NRF) curies values.

Selected Isotopes[a]	HDT and RPDT[b]	Little et al. (2001)	NR:IBO Letters[c]	RI/FS Snapshot[d]
Am-241	2.90E-02	8.50E-04	1.19E+01	1.19E+01
C-14	1.87E+01	5.70E-01	7.34E+01	7.34E+01
Cl-36	9.21E-02	8.29E-03	2.16E-01	2.16E-01
Cm-244	3.24E-02	8.79E-03	No data	8.79E-03
Co-60	1.46E+06	1.47E+03	7.36E+05	7.36E+05
Cs-137	2.70E+05	9.47E-02	1.15E+04	1.15E+04
Eu-152	6.32E-01	5.27E-02	No data	5.27E-02
Eu-154	1.11E+02	7.55E+00	No data	7.55E+00
H-3	3.56E+01	2.70E+00	1.99E+02	1.99E+02
I-129	9.05E-04	7.54E-07	9.21E-03	9.21E-03
Nb-94	1.56E+01	1.56E-01	3.17E+01	3.17E+01
Ni-59	1.77E+03	2.33E+01	1.90E+03	1.90E+03
Ni-63	7.51E+05	2.78E+03	1.93E+05	1.93E+05
Np-237	No data	No data	4.39E-03	4.39E-03
Pu-238	2.80E-02	7.43E-04	1.89E+01	1.89E+01
Pu-239	8.62E-03	1.13E-04	4.68E+01	4.68E+01
Pu-240	3.85E-03	1.25E-04	4.07E+01	4.07E+01
Pu-241	4.76E-01	6.85E-02	3.21E+03	3.21E+03
Sr-90	2.70E+05	1.19E-01	6.94E+03	6.94E+03
Tc-99	2.27E-01	7.31E-04	2.88E+00	2.88E+00
U-233	7.12E-07	No data	4.27E-04	4.27E-04
U-234	1.77E-06	1.77E-06	8.44E-02	8.44E-02
U-235	2.98E-06	2.98E-06	1.66E-03	1.66E-03
U-236	No data	No data	1.20E-02	1.20E-02
U-238	1.82E-06	1.82E-06	8.33E-02	8.33E-02

a. Isotopes are a list of selected contaminants of concern.

b. NRF identified waste streams and isotope values and provided these values to OU 7 13/14. This NRF evaluation accounts for all changes to HDT and RPDT values.

c. W. R. Dixon, Naval Reactors Idaho Branch Office, to J. G. Snook, U.S. Department of Energy Idaho Operations Office, "Subsurface Disposal Area Inventory," Letter NR:IBO-04/045, March 24, 2004.

W. R. Dixon, Naval Reactors Idaho Branch Office, to J. N. Perry, U.S. Department of Energy Idaho Operations Office, "Review of Attachments to DOE Memorandum Dated July 14, 2004; Concurrence with Comments," Letter NR:IBO-04/122, August 13, 2004.

d. The RI/FS Snapshot values reflect the Dixon (2004a, 2004b) and Little et al. (2001) report values.

B-5. MATERIALS AND FUELS COMPLEX

Isotope values from the HDT and RPDT were updated based on the Carboneau and Vail's (2004) evaluation of disposal data and the use of ORIGEN2 models to develop more comprehensive isotope values. Data from Carboneau and Vail were partitioned (see Section 4 of this report) to individual shipments for input in WILD. During partitioning, a typographical error was found in the Carboneau and Vail's Summary Table B-12, Sections 1 and 3; correction of this error accounts for the differences between Carboneau and Vail and isotope values in WILD for the Materials and Fuels Complex (MFC; formerly Argonne National Laboratory-West). Isotope values in the RI/FS Snapshot are the sum of values from Appendix C of this report and the RPDT Supplement (Little et al. 2001). These values are shown in Table B-5.

Table B-5. Materials and Fuels Complex (MFC; formerly Argonne National Laboratory-West) nuclide values (curies).

Selected Isotopes[a]	HDT and RPDT[b]	Carboneau & Vail 1951-1993	1951–1993 (See App. C this report)	RPDT Supplement 1994–2000	RI/FS Snapshot[d]
Ac-227	No data	No data	No data	1.01E-09	1.01E-09
Am-241	1.80E-07	3.03E+00	3.03E+00	1.60E-02	3.05E+00
Am-243	No data	No data	No data	2.10E-10	2.10E-10
C-14	No data	3.15E+01[c]	3.15E+01	7.11E+00	3.86E+01
Cl-36	No data	7.98E-03[c]	7.98E-03	No data	7.98E-03
Cm-244	No data	No data	No data	8.73E-05	8.73E-05
Co-60	1.45E+06	1.54E+06[c]	1.54E+06	1.02E+04	1.55E+06
Cs-137	1.43E+05	2.78E+04	2.78E+04	1.89E+01	2.78E+04
Eu-152	No data	1.41E+00	1.41E+00	1.27E-03	1.41E+00
Eu-154	5.77E-01	1.47E+02	1.47E+02	1.10E-01	1.47E+02
H-3	8.19E+01	1.49E+02[c]	1.49E+02	7.79E-01	1.50E+02
I-129	No data	7.01E-03	7.01E-03	1.56E-03	8.57E-03
Na-22	5.30E-01	No data	No data	3.67E+02	3.67E+02
Nb-94	No data	5.38E+00	5.38E+00	2.68E-01	5.65E+00
Ni-59	No data	1.65E+02[c]	1.65E+02	2.07E+01	1.86E+02
Ni-63	No data	1.20E+04	1.20E+04	1.01E+03	1.30E+04
Np-237	No data	2.67E-02	2.67E-02	7.59E-03	3.43E-02
Pa-231	No data	No data	No data	1.60E-08	1.60E-08
Pb-210	No data	No data	No data	No data	No data
Pu-238	2.23E-02	1.15E+01	1.15E+01	2.04E-02	1.15E+01
Pu-239	1.26E+01	5.12E+02	5.12E+02	3.60E-02	5.12E+02
Pu-240	8.07E-03	7.04E+00	7.04E+00	2.75E-02	7.07E+00
Pu-241	No data	1.21E+02	1.21E+02	1.44E+00	1.23E+02
Pu-242	No data	1.94E-03	1.94E-03	1.03E-09	1.94E-03
Ra-226	No data	2.00E-01	2.00E-01	1.00E-10	2.00E-01
Ra-228	No data	No data	No data	No data	No data
Sr-90	2.29E+05	2.01E+04	2.01E+04	1.80E+01	2.01E+04
Tc-99	No data	1.65E+01	1.65E+01	2.64E-03	1.65E+01
Th-228	No data	No data	No data	1.66E-06	1.66E-06
Th-229	No data	No data	No data	3.40E-10	3.40E-10
Th-230	No data	No data	No data	2.02E-07	2.02E-07
Th-232	1.00E-05	9.63E-04	9.63E-04	No data	9.63E-04
U-232	No data	No data	No data	4.70E-06	4.70E-06
U-233	No data	No data	No data	5.69E-04	5.69E-04
U-234	5.90E+00	3.37E+00	3.37E+00	1.69E-03	3.37E+00
U-235	3.80E-01	1.45E-01	1.45E-01	3.18E-03	1.49E-01
U-236	No data	1.08E-01	1.08E-01	No data	1.08E-01
U-238	1.76E+00	1.38E+00	1.38E+00	1.66E-03	1.39E+00

a. Isotopes are a list of selected contaminants of interest.

b. Changes from HDT and RPDT (LMITCO 1995a and 1995b) values to Carboneau and Vail (2004) values occurred when engineering models were applied to facility information on waste produced. Models reported additional isotopes and did not report all isotopes addressed in HDT and RPDT.

c. Typographical errors in Table B-12, Parts 1 and 3 (Carboneau and Vail 2004), for waste streams ANL-MOD-2H and ANL-MOD-2HEXT were corrected. Values shown are corrected.

d. The RI/FS Snapshot is the sum of values from the Waste Information and Location Database and RPDT Supplement (Little et al. 2001).

B-6. ROCKY FLATS PLANT

The HDT and RPDT values were updated based on retrieval of Rocky Flats Plant (RFP) waste from Pits 11 and 12 and Blackwood and Hoffman (2004) data from the Transuranic Storage Area (TSA) assay project for stored transuranic waste. This document identified the under-reporting of Am-241 and U-238 in the shipping records from RFP, based on the assay data of waste going through the Stored Waste Examination Pilot Plant. Isotope values in the RI/FS Snapshot are the product of subtracting RFP waste retrieved from Pits 11 and 12, and TSA assay adjustments to Am-241 and U-238 values. These values are shown in Table B-6.

Table B-6. Rocky Flats Plant (RFP) nuclide values (curies).

Isotope[a]	HDT[b]	Subtract Pits 11 and 12 Retrieval	Add TSA Assay Adjustment	RI/FS Snapshot[c]
Am-241	1.52E+05	5.04E+03	8.35E+04	2.30E+05
Co-60	1.74E+02	2.26E+01	No data	1.51E+02
Cs-137	2.14E+02	8.35E+01	No data	1.31E+02
H-3	3.60E-01	1.40E-01	No data	2.20E-01
Pu-238	1.91E+03	6.40E+01	No data	1.85E+03
Pu-239	6.52E+04	2.18E+03	No data	6.30E+04
Pu-240	1.46E+04	4.88E+02	No data	1.41E+04
Pu-241	3.90E+05	1.31E+04	No data	3.77E+05
Pu-242	8.78E-01	2.96E-02	No data	8.48E-01
Ra-226	1.90E-01	2.08E-02	No data	1.69E-01
U-232	1.24E-02	No data	No data	1.24E-02
U-233	5.40E-01	No data	No data	5.40E-01
U-234	4.27E+01	2.09E+00	No data	4.07E+01
U-235	2.26E+00	1.06E-01	No data	2.15E+00
U-236	1.04E+00	5.69E-02	No data	9.83E-01
U-238	1.05E+02	4.41E+00	2.79E+01	1.29E+02

a. Isotopes are a list of selected contaminants of concern.

b. Changes from HDT values were caused by removing Pits 11 and 12 retrieved waste and addition caused by the TSA assay data.

c. The RI/FS Snapshot values are adjusted for Pits 11 and 12 retrieval and the assay corrections.

B-7. CHEMICAL CONTAMINANT DATA

The HDT values were updated based on the retrieval of RFP waste from Pits 11 and 12, Varvel (2005), and Miller and Varvel (2005). The contaminants of concern of carbon tetrachloride, methylene chloride, tetrachloroethylene (also known as PCE), and nitrates are a subset of contaminants listed in the HDT and are reflected in WILD. These values are shown in Table B-7.

Table B-7. Chemical contaminants.

Chemical Contaminant Data			
Contaminants of Concern	HDT and RPDT	Corrections Plus or Minus (g)	Corrected Values (g)
Carbon tetrachloride	1.65E+08	7.86E+08	7.90E+08[a]
Methylene chloride	1.94E+07	-5.30E+6	1.41E+07[b]
Nitrates from grams of nitrogen	3.24E+09	-2.78E+9	4.56E+08[b]
Tetrachloroethylene (also known as PCE)	3.60E+07	6.27E+7	9.87E+07[a]
Chromium	2.32E+06	No change	2.32E+06
a. Miller and Varvel (2005) corrections.			
b. Value corrected to account for waste removed from Pits 11 and 12.			

B-8. OTHER FACILITIES

The HDT and RPDT addressed other facilities and generators of waste, both on and off the Idaho National Laboratory (INL). Facilities and generators on INL were the Auxiliary Reactor Area, Central Facility Area, deactivation and decommissioning activities, Power Burst Facility, and Waste Experimental Reduction Facility. Data from other INL facilities have not been refined to date. However, data from these facilities are scheduled to be partitioned to the waste shipment level in Fiscal Year 2005.

In addition, there are several miscellaneous off-INL generators. Except for data from the U.S. Bureau of Mines, data from off-INL generators have not been refined. These data are also scheduled for partitioning to individual waste shipment in Fiscal Year 2005. The U.S. Bureau of Mines data were refined in Fuhrman (see Appendix E of this report), and the amount of Cl-36 was reduced. Isotope values in the RI/FS Snapshot are the sum of values from Appendix C of this report and the RPDT Supplement (Little et al. 2001). These values are shown in Table B-8.

Table B-8. Other facilities' nuclide values (curies).

Isotope[a]	HDT and RPDT[b]	Fuhrman[c]	RPDT Supplement 1994–2000	RI/FS Snapshot[d]
Ac-227	No data	No data	9.60E-07	9.60E-07
Am-241	3.06E-01	No data	2.52E-02	3.31E-01
Am-243	9.23E-06	No data	5.31E-06	1.45E-05
C-14	6.84E-01	No data	3.57E-01	1.04E+00
Cl-36	3.14E-01	5.00E-06	1.30E-10	5.00E-06
Cm-244	9.86E-04	No data	No data	No data
Co-60	4.87E+03	No data	No data	No data
Cs-137	2.63E+04	No data	No data	No data
Eu-152	3.06E-01	No data	No data	No data
Eu-154	4.61E-01	No data	No data	No data
H-3	1.19E+04	No data	No data	No data
I-129	No data	No data	No data	No data
Na-22	3.15E-01	No data	No data	No data
Nb-94	2.00E+00	No data	No data	No data
Ni-59	4.65E+02	No data	No data	No data
Ni-63	6.73E+02	No data	No data	No data
Np-237	8.49E-04	No data	No data	No data
Pa-231	No data	No data	No data	No data
Pb-210	9.10E-06	No data	No data	No data
Pu-238	2.02E-01	No data	No data	No data
Pu-239	5.00E+02	No data	No data	No data
Pu-240	4.50E+02	No data	No data	No data
Pu-241	9.60E-02	No data	No data	No data
Pu-242	1.45E-05	No data	No data	No data
Ra-226	6.67E+01	No data	No data	No data
Ra-228	No data	No data	No data	No data
Sr-90	8.21E+03	No data	No data	No data
Tc-99	2.00E-06	No data	No data	No data
Th-228	1.02E+01	No data	No data	No data
Th-229	No data	No data	No data	No data
Th-230	1.79E-02	No data	No data	No data
Th-232	1.32E+00	No data	No data	No data
U-232	2.21E+00	No data	No data	No data
U-233	6.00E-01	No data	No data	No data
U-234	1.02E+01	No data	No data	No data
U-235	6.27E-01	No data	No data	No data
U-236	No data	No data	No data	No data
U-238	6.29E+00	No data	4.05E-01	6.69E+00

a. Isotopes are a list of selected contaminants of concern.

b. There have been no changes from HDT and RPDT values for years 1951-1993. The RPDT Supplement (Little et al. 2001) updated 1994-1999.

c. Fuhrman's review of U.S. Bureau of Mines data (Appendix E of this report) indicated that HDT and RPDT values for Cl-36 should be refined, and the amount of Cl-36 from this source has been overestimated.

d. The RI/FS Snapshot is the sum of values from the Waste Information and Location Database and RPDT Supplement (Little et al. 2001).

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Appendix C

Summary of Radiological Inventory from the Waste Information and Location Database

CONTENTS

TABLES

Appendix C

Summary of Radiological Inventory from the Waste Information and Location Database

The values presented in this appendix are historical and were taken from WILD in February 2005. They are provided to establish the baseline values for the major Idaho National Laboratory facilities used in the development of the RI/FS Snapshot.

Table C-1. Waste stream nuclide values from the Materials and Fuels Complex (MFC; formerly Argonne National Laboratory-West). (Data were taken from WILD in February 2005.)

Nuclide	ANL-MOD-1H	ANL-MOD-1R	ANL-MOD-2H	ANL-MOD-2HEXT	ANL-MOD-2R	ANL-MOD-3H	ANL-MOD-3R	ANL-MOD-4H	ANL-MOD-4R	ANL-MOD-5H	Total
Am-241	no data	no data	5.27E-01	4.38E-01	no data	4.65E-01	7.15E-02	no data	1.10E-02	1.52E+00	3.03E+00
C-14	1.60E+01	1.53E+01	1.61E-02	1.33E-02	no data	1.42E-02	2.19E-03	no data	3.38E-04	4.65E-02	3.15E+01
Cl-36	4.06E-03	3.81E-03	1.99E-05	1.66E-05	no data	1.76E-05	2.70E-06	no data	4.17E-07	5.75E-05	7.98E-03
Co-60	8.09E+05	7.35E+05	9.23E+01	7.68E+01	no data	8.16E+01	1.26E+01	no data	1.93E+00	2.67E+02	1.54E+06
Cs-137	no data	no data	4.82E+03	4.00E+03	no data	4.26E+03	6.55E+02	no data	1.01E+02	1.39E+04	2.78E+04
Eu-152	no data	no data	2.45E-01	2.04E-01	no data	2.16E-01	3.33E-02	no data	5.12E-03	7.07E-01	1.41E+00
Eu-154	no data	no data	2.55E+01	2.12E+01	no data	2.26E+01	3.48E+00	no data	5.36E-01	7.38E+01	1.47E+02
H-3	no data	no data	2.36E+01	1.97E+01	no data	2.09E+01	3.22E+00	1.33E+01	4.96E-01	6.83E+01	1.49E+02
I-129	no data	no data	1.22E-03	1.01E-03	no data	1.08E-03	1.65E-04	no data	2.55E-05	3.52E-03	7.01E-03
Nb-94	2.81E+00	2.55E+00	2.66E-03	2.21E-03	no data	2.35E-03	3.61E-04	no data	5.57E-05	7.68E-03	5.38E+00
Ni-59	8.58E+01	7.89E+01	4.83E-02	4.01E-02	no data	4.26E-02	6.57E-03	no data	1.01E-03	1.39E-01	1.65E+02
Ni-63	6.27E+03	5.73E+03	1.86E+00	1.55E+00	no data	1.64E+00	2.53E-01	no data	3.90E-02	5.37E+00	1.20E+04
Np-237	no data	no data	3.88E-03	3.23E-03	no data	3.43E-03	5.27E-04	4.37E-03	8.12E-05	1.12E-02	2.67E-02
Pu-238	no data	no data	2.00E+00	1.67E+00	no data	1.77E+00	2.72E-01	no data	4.20E-02	5.78E+00	1.15E+01
Pu-239	no data	no data	7.99E+01	6.64E+01	no data	7.05E+01	1.09E+01	5.16E+01	1.67E+00	2.31E+02	5.12E+02
Pu-240	no data	no data	1.22E+00	1.02E+00	no data	1.08E+00	1.66E-01	no data	2.56E-02	3.53E+00	7.04E+00
Pu-241	no data	no data	2.10E+01	1.75E+01	no data	1.86E+01	2.86E+00	no data	4.41E-01	6.07E+01	1.21E+02
Pu-242	no data	no data	3.36E-04	2.79E-04	no data	2.97E-04	4.57E-05	no data	7.03E-06	9.71E-04	1.94E-03
Ra-226	no data	no data	5.18E-08	4.30E-08	no data	4.57E-08	7.04E-09	2.00E-01	1.08E-09	1.50E-07	2.00E-01
Sr-90	no data	no data	3.48E+03	2.90E+03	no data	3.08E+03	4.74E+02	no data	7.30E+01	1.01E+04	2.01E+04
Tc-99	6.88E+00	6.24E+00	5.89E-01	4.90E-01	no data	5.20E-01	8.01E-02	no data	1.23E-02	1.70E+00	1.65E+01

Table C-1. (continued).

Nuclide	ANL-MOD-1H	ANL-MOD-1R	ANL-MOD-2H	ANL-MOD-2HEXT	ANL-MOD-2R	ANL-MOD-3H	ANL-MOD-3R	ANL-MOD-4H	ANL-MOD-4R	ANL-MOD-5H	Total
Th-232	no data	no data	1.25E-04	1.04E-04	no data	1.11E-04	1.70E-05	2.42E-04	2.62E-06	3.61E-04	9.63E-04
U-234	no data	no data	2.91E-01	2.42E-01	9.47E-01	2.57E-01	3.96E-02	7.48E-01	6.09E-03	8.41E-01	3.37E+00
U-235	no data	no data	1.19E-02	9.87E-03	4.28E-02	1.05E-02	1.61E-03	3.43E-02	2.49E-04	3.42E-02	1.45E-01
U-238	no data	no data	2.28E-03	1.89E-03	8.04E-02	2.01E-03	3.10E-04	1.29E+00	4.78E-05	6.58E-03	1.38E+00

Table C-2. Idaho Nuclear Technology and Engineering Center (INTEC) waste stream nuclide values. (Data were taken from WILD in February 2005.)

Nuclide	INTEC-MOD-1H	INTEC-MOD-1R	INTEC-MOD-2H	INTEC-MOD-2R	INTEC-MOD-3H	INTEC-MOD-3R	INTEC-MOD-4H	INTEC-MOD-5H	INTEC-MOD-6H	INTEC-MOD-7H	INTEC-MOD-8H	INTEC-MOD-9H	Total
Ac-227	No data	1.79E-08	4.69E-08	2.99E-09	No data	2.46E-09	1.03E-07	4.32E-07	2.68E-07	2.63E-07	No data	7.68E-07	1.90E-06
Am-241	No data	5.55E-02	1.77E-05	9.33E-03	No data	7.66E-03	3.19E-01	1.34E+00	1.04E-04	8.21E-01	No data	2.40E+00	4.95E+00
Am-242	No data	No data	No data	No data	No data	No data	1.47E-07	No data	No data	No data	No data	No data	1.47E-07
Am-243	No data	5.26E-04	5.52E-12	8.69E-05	No data	7.33E-05	8.43E-09	1.26E-02	3.18E-11	7.70E-03	No data	2.24E-02	4.34E-02
C-14	No data	3.02E-07	5.63E-05	5.00E-08	No data	4.11E-08	7.30E-07	7.22E-06	1.13E-02	4.47E-06	2.56E+00	1.28E-05	2.57E+00
Cl-36	No data	No data	No data	No data	No data	No data	No data	No data	5.99E-06	No data	1.40E-03	No data	1.41E-03
Cm-242	No data	No data	No data	No data	No data	No data	1.22E-07	No data	No data	No data	No data	No data	1.22E-07
Cm-244	No data	1.02E-03	2.76E-12	1.71E-04	No data	1.42E-04	5.37E-08	2.46E-02	1.60E-11	1.48E-02	No data	4.32E-02	8.39E-02
Cm-247	No data	9.47E-15	No data	1.57E-15	No data	1.32E-15	2.54E-21	2.28E-13	No data	1.40E-13	No data	4.08E-13	7.88E-13
Cm-248	No data	1.13E-14	No data	1.88E-15	No data	1.56E-15	5.03E-22	2.77E-13	No data	1.73E-13	No data	4.88E-13	9.53E-13
Co-60	No data	2.34E-01	No data	3.87E-02	No data	3.23E-02	6.49E-01	5.64E+00	6.92E+02	3.48E+00	1.65E+05	9.59E+00	1.66E+05
Cs-137	No data	1.88E+02	4.69E+04	3.13E+01	No data	2.60E+01	5.37E+02	4.51E+03	4.12E+03	2.77E+03	No data	8.00E+03	6.70E+04
Eu-152	No data	1.33E-02	2.46E-01	2.26E-03	No data	1.84E-03	5.72E-02	3.21E-01	2.98E-01	2.01E-01	No data	5.68E-01	1.71E+00
Eu-154	No data	2.42E+00	3.99E+01	4.01E-01	No data	3.37E-01	1.06E+01	5.87E+01	5.39E+01	3.63E+01	No data	1.04E+02	3.06E+02
H-3	No data	5.33E-01	3.41E+02	8.90E-02	No data	7.43E-02	1.78E+00	1.29E+01	1.19E+01	7.90E+00	No data	2.24E+01	3.99E+02
I-129	No data	5.93E-05	1.80E-02	9.98E-06	No data	8.40E-06	1.47E-04	1.44E-03	1.33E-03	8.84E-04	No data	2.56E-03	2.45E-02
Nb-94	No data	5.81E-08	8.44E-06	9.66E-09	No data	8.08E-09	1.39E-07	1.40E-06	2.53E-03	8.62E-07	5.84E-01	2.48E-06	5.87E-01
Ni-59	No data	6.26E-04	No data	1.04E-04	No data	8.73E-05	No data	1.51E-02	6.20E-02	9.35E-03	1.13E+01	2.64E-02	1.14E+01
Ni-63	No data	4.21E-02	No data	7.16E-03	No data	5.92E-03	3.01E-01	1.02E+00	4.57E+00	6.24E-01	8.37E+02	1.84E+00	8.46E+02
Np-237	No data	6.42E-05	1.32E-04	1.07E-05	No data	8.95E-06	1.05E-04	1.55E-03	7.74E-04	9.46E-04	No data	2.72E-03	6.31E-03
Pa-231	No data	4.73E-08	7.61E-07	7.82E-09	No data	6.57E-09	No data	1.14E-06	4.42E-06	6.96E-07	No data	2.00E-06	9.08E-06
Pb-210	No data	4.84E-10	3.18E-10	8.14E-11	No data	6.79E-11	7.87E-13	1.17E-08	1.89E-09	7.27E-09	No data	2.08E-08	4.26E-08
Pu-238	No data	7.80E-01	1.75E-02	1.30E-01	No data	1.09E-01	5.47E+00	1.88E+01	1.03E-01	1.15E+01	No data	3.36E+01	7.06E+01
Pu-239	No data	1.29E-02	7.19E-01	2.15E-03	1.81E-01	1.82E-03	6.95E-02	3.10E-01	4.13E+00	1.89E-01	No data	5.52E-01	6.17E+00
Pu-240	No data	1.01E-02	5.32E-03	1.70E-03	No data	1.39E-03	6.49E-02	2.41E-01	3.13E-02	1.47E-01	No data	4.24E-01	9.26E-01

Table C-2. (continued).

Nuclide	INTEC-MOD-1H	INTEC-MOD-1R	INTEC-MOD-2H	INTEC-MOD-2R	INTEC-MOD-3H	INTEC-MOD-3R	INTEC-MOD-4H	INTEC-MOD-5H	INTEC-MOD-6H	INTEC-MOD-7H	INTEC-MOD-8H	INTEC-MOD-9H	Total
Pu-241	No data	1.13E+00	3.16E-03	1.87E-01	No data	1.54E-01	7.74E+00	2.74E+01	1.88E-02	1.72E+01	No data	4.88E+01	1.03E+02
Pu-242	No data	2.07E-05	1.33E-10	3.44E-06	No data	2.89E-06	1.42E-04	5.01E-04	7.84E-10	3.06E-04	No data	8.80E-04	1.86E-03
Pu-244	No data	3.10E-13	1.55E-21	5.32E-14	No data	4.41E-14	2.47E-17	7.58E-12	9.13E-21	4.68E-12	No data	1.36E-11	2.63E-11
Ra-226	No data	6.94E-08	8.12E-09	1.15E-08	1.68E-04	9.59E-09	9.13E-12	1.66E-06	4.69E-08	1.02E-06	No data	2.96E-06	1.73E-04
Ra-228	No data	1.04E-11	5.21E-14	1.72E-12	No data	1.46E-12	3.76E-13	2.51E-10	3.02E-13	1.58E-10	No data	4.48E-10	8.71E-10
Sr-90	No data	1.90E+02	4.26E+04	3.15E+01	No data	2.63E+01	7.18E+02	4.56E+03	4.24E+03	2.78E+03	No data	8.00E+03	6.32E+04
Tc-99	No data	3.69E-02	6.67E+00	6.19E-03	No data	5.18E-03	9.02E-02	8.94E-01	8.20E-01	5.51E-01	2.84E-01	1.60E+00	1.10E+01
Th-228	No data	3.15E-03	3.47E-05	5.32E-04	No data	4.42E-04	3.94E-06	7.77E-02	2.06E-04	4.78E-02	No data	1.36E-01	2.66E-01
Th-229	No data	1.48E-10	9.90E-10	2.44E-11	No data	2.02E-11	3.22E-11	3.57E-09	5.84E-09	2.18E-09	No data	6.32E-09	1.91E-08
Th-230	No data	2.58E-07	9.38E-06	4.30E-08	No data	3.55E-08	5.03E-09	6.23E-06	5.51E-05	3.84E-06	No data	1.12E-05	8.61E-05
Th-232	No data	4.81E-13	3.15E-13	8.14E-14	1.15E-02	6.79E-14	1.31E-12	1.17E-11	1.87E-12	7.17E-12	No data	2.08E-11	1.15E-02
U-232	No data	6.46E-06	5.01E-05	1.09E-06	No data	9.05E-07	2.27E-08	1.57E-04	2.97E-04	9.56E-05	No data	2.80E-04	8.88E-04
U-233	No data	9.30E-09	1.89E-06	1.56E-09	No data	1.28E-09	2.37E-10	2.24E-07	1.10E-05	1.37E-07	No data	4.00E-07	1.37E-05
U-234	6.63E-02	6.58E-04	2.67E-01	1.10E-04	3.88E-01	9.16E-05	7.26E-02	1.58E-02	1.56E+00	9.76E-03	No data	2.80E-02	2.40E+00
U-235	2.34E-03	4.26E-06	9.06E-03	7.16E-07	9.47E-01	5.93E-07	2.43E-03	1.03E-04	5.38E-02	6.34E-05	No data	1.84E-04	1.01E+00
U-238	9.93E-02	2.21E-07	1.28E-03	3.71E-08	2.32E-01	3.07E-08	2.56E-06	5.33E-06	7.39E-03	3.33E-06	No data	9.59E-06	3.40E-01

Table C-3. Naval Reactors Facility (NRF) waste stream nuclide values. Waste streams NRF-MOD-1H to NRF-MOD-9H reference to NR IBO-04/045 as modified by NR IBO-04/122. (Data were taken from WILD in February 2005.)

Nuclide	NRF-MOD-1H	NRF-MOD-2H	NRF-MOD-3H	NRF-MOD-4H	NRF-MOD-5H	NRF-MOD-6H	NRF-MOD-6R	NRF-MOD-7H	NRF-MOD-8H	NRF-MOD-9H	NRF-MOD-10H	NRF-MOD-10R	Total
Am-241	1.08E+01	2.85E-01	2.38E-03	1.52E-03	2.51E-01	1.09E-01	3.09E-02	1.78E-03	1.78E-03	8.95E-03	4.19E-01	7.42E-03	1.19E+01
C-14	2.84E-02	7.49E-04	2.36E-07	1.51E-07	6.60E-04	3.82E+01	1.08E+01	3.28E+00	4.05E+00	1.65E+01	0.00E+00	0.00E+00	7.34E+01
Cl-36	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.58E-01	4.49E-02	4.95E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.16E-01
Cm-244	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	8.79E-03
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.75E+05	1.35E+05	0.00E+00	5.05E+02	2.54E+03	1.19E+05	2.10E+03	7.36E+05
Cs-137	1.06E+04	2.80E+02	2.07E+02	1.33E+02	2.46E+02	7.09E+00	2.01E+00	4.49E-01	2.03E-01	1.02E+00	4.78E+01	8.46E-01	1.15E+04
Eu-152	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	5.27E-02
Eu-154	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	7.55E+00
H-3	4.62E+01	1.22E+00	8.17E-01	5.23E-01	1.07E+00	1.09E+02	3.09E+01	6.70E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E+02
I-129	3.90E-03	1.06E-04	4.94E-05	3.16E-05	9.06E-05	3.82E-05	1.08E-05	1.73E-07	2.03E-05	1.01E-04	4.78E-03	8.46E-05	9.21E-03
Nb-94	1.37E-05	3.62E-07	8.59E-08	5.50E-08	3.19E-07	5.06E+00	1.44E+00	2.74E-03	1.02E-01	5.10E-01	2.40E+01	4.25E-01	3.17E+01
Ni-59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E+03	3.31E+02	3.93E-02	1.52E+00	7.65E+00	3.58E+02	6.33E+00	1.90E+03
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E+05	3.76E+04	4.97E+00	1.52E+02	7.65E+02	1.90E+04	3.36E+02	1.93E+05
Np-237	2.66E-03	7.03E-05	9.70E-04	6.20E-04	6.19E-05	0.00E+00	0.00E+00	1.16E-06	1.52E-08	7.65E-08	3.58E-06	6.33E-08	4.39E-03
Pu-238	1.18E+01	3.12E-01	3.75E+00	2.40E+00	2.75E-01	6.93E-02	1.97E-02	2.37E-03	1.27E-03	6.40E-03	2.99E-01	5.29E-03	1.89E+01
Pu-239	4.43E+01	1.17E+00	7.74E-03	4.96E-03	1.03E+00	1.64E-01	4.64E-02	1.35E-02	2.03E-04	1.02E-03	4.78E-02	8.46E-04	4.68E+01
Pu-240	3.86E+01	1.02E+00	2.23E-03	1.42E-03	8.98E-01	1.01E-01	2.87E-02	4.72E-03	1.27E-04	6.40E-04	2.99E-02	5.29E-04	4.07E+01
Pu-241	3.03E+03	8.01E+01	1.14E+00	7.30E-01	7.05E+01	8.57E+00	2.43E+00	3.13E-01	5.05E-02	2.55E-01	1.18E+01	2.09E-01	3.21E+03
Sr-90	6.24E+03	1.65E+02	2.06E+02	1.32E+02	1.45E+02	3.74E+00	1.06E+00	2.72E-01	2.03E-01	1.02E+00	4.78E+01	8.46E-01	6.94E+03
Tc-99	1.49E+00	3.93E-02	2.85E-02	1.83E-02	3.46E-02	2.03E-02	5.74E-03	9.02E-05	5.05E-03	2.56E-02	1.19E+00	2.10E-02	2.88E+00
U-233	1.44E-06	3.80E-08	4.27E-07	2.73E-07	3.35E-08	0.00E+00	0.00E+00	8.79E-05	1.37E-06	6.90E-06	3.23E-04	5.71E-06	4.27E-04
U-234	6.95E-02	1.53E-03	7.01E-03	4.49E-03	1.35E-03	1.09E-04	3.09E-05	7.87E-06	1.52E-06	7.70E-06	3.58E-04	6.33E-06	8.44E-02
U-235	1.47E-03	2.49E-05	8.60E-05	5.50E-05	2.20E-05	3.12E-06	8.84E-07	2.00E-07	1.07E-10	5.35E-10	2.52E-08	4.46E-10	1.66E-03
U-238	7.97E-02	1.81E-03	3.75E-07	2.40E-07	1.59E-03	1.17E-04	3.31E-05	7.07E-06	2.49E-08	1.25E-07	5.86E-06	1.04E-07	8.33E-02

Table C-4. Test Area North (TAN) waste stream nuclide values. (Data were taken from WILD in February 2005.)

Nuclide	TAN-607-2N	TAN-607-3N	TAN-607-5N	TAN-607-6RN	TAN-633-2N	TAN-633-3N	TAN-633-4N	TAN-633-5N	Total
Ac-227	2.62E-08	2.45E-07	1.77E-08	7.09E-08	6.24E-08	5.32E-09	3.24E-08	2.14E-07	6.74E-07
Am-241	1.15E-02	1.63E-01	9.26E-02	7.94E-02	1.85E-04	3.57E-01	3.19E-01	4.33E-02	1.07E+00
Am-243	8.82E-06	1.25E-04	6.97E-05	3.93E-06	1.42E-07	2.74E-04	2.45E-04	3.20E-05	7.59E-04
C-14	8.39E-07	6.44E-05	4.13E-05	2.41E-06	1.03E-06	4.32E-07	7.27E-06	1.39E-05	1.32E-04
Cl-36	3.11E-04	5.19E-05	6.36E-03	2.56E-04	6.38E-06	no data	1.44E-03	2.20E-03	1.06E-02
Cm-244	1.44E-04	2.04E-03	1.13E-03	1.61E-05	2.32E-06	4.47E-03	3.99E-03	5.21E-04	1.23E-02
Co-60	3.86E+02	1.24E+02	6.68E+03	4.13E+02	4.37E+01	no data	1.72E+03	2.51E+03	1.19E+04
Cs-137	2.38E+01	1.20E+03	4.82E+02	1.74E+03	2.95E+01	3.60E+02	4.58E+02	4.05E+02	4.70E+03
Eu-152	7.02E-04	1.19E-02	1.79E-02	5.57E-02	1.84E-05	2.17E-02	2.02E-02	6.62E-03	1.35E-01
Eu-154	1.91E-01	3.14E+00	3.00E+00	6.85E+00	4.19E-03	5.93E+00	5.42E+00	1.35E+00	2.59E+01
H-3	9.61E-02	4.82E+00	1.93E+00	7.05E+00	1.13E-01	1.54E+00	1.90E+00	1.80E+00	1.93E+01
I-129	6.22E-06	2.95E-04	1.19E-04	4.32E-04	7.49E-06	9.71E-05	1.20E-04	1.25E-04	1.20E-03
Nb-94	1.42E-06	6.48E-07	3.01E-05	2.07E-06	6.85E-09	1.95E-07	6.71E-06	3.41E-05	7.52E-05
Ni-59	2.53E-01	2.07E-01	3.09E+00	4.91E-01	1.15E-01	no data	1.18E+00	2.17E+00	7.51E+00
Ni-63	3.48E+01	2.83E+01	4.19E+02	5.96E+01	1.56E+01	no data	1.62E+02	2.84E+02	1.00E+03
Np-237	1.67E-05	3.10E-04	2.53E-04	9.23E-04	5.64E-07	5.16E-04	4.72E-04	4.03E-04	2.90E-03
Pa-231	4.26E-07	5.18E-06	3.35E-07	1.36E-06	1.02E-06	8.28E-08	5.33E-07	1.90E-06	1.08E-05
Pb-210	1.94E-10	1.28E-09	9.09E-11	3.93E-10	4.65E-10	no data	2.16E-10	3.20E-09	5.84E-09
Pu-238	2.29E-02	3.28E-01	2.16E-01	3.24E-01	3.70E-04	7.13E-01	6.36E-01	2.68E-01	2.51E+00
Pu-239	6.35E-02	1.32E+00	6.49E-01	5.92E+00	1.86E-03	1.97E+00	1.76E+00	2.77E+00	1.45E+01
Pu-240	3.32E-02	4.79E-01	2.83E-01	8.37E-01	5.38E-04	1.03E+00	9.21E-01	2.03E-01	3.79E+00
Pu-241	2.12E+00	3.02E+01	1.71E+01	1.50E+01	3.42E-02	6.59E+01	5.88E+01	7.89E+00	1.97E+02
Pu-242	4.93E-06	7.01E-05	3.91E-05	8.61E-06	7.96E-08	1.53E-04	1.37E-04	1.79E-05	4.31E-04
Ra-226	4.87E-09	4.22E-08	2.94E-09	1.20E-08	1.16E-08	7.24E-10	5.83E-09	4.20E-08	1.22E-07

Table C-4. (continued).

Nuclide	TAN-607-2N	TAN-607-3N	TAN-607-5N	TAN-607-6RN	TAN-633-2N	TAN-633-3N	TAN-633-4N	TAN-633-5N	Total
Sr-90	2.21E+01	1.15E+03	4.57E+02	1.65E+03	2.83E+01	3.22E+02	4.20E+02	3.74E+02	4.42E+03
Tc-99	3.79E-03	1.83E-01	7.64E-02	2.60E-01	4.47E-03	5.24E-02	6.91E-02	6.69E-02	7.15E-01
Th-228	4.21E-07	1.83E-05	8.24E-06	2.71E-05	3.70E-07	8.36E-06	9.15E-06	3.27E-05	1.05E-04
Th-229	no data	1.19E-10	5.68E-11	2.48E-10	no data	no data	1.51E-11	4.19E-10	8.58E-10
Th-230	5.61E-06	6.39E-05	4.13E-06	1.69E-05	1.34E-05	9.48E-07	6.91E-06	2.52E-05	1.37E-04
U-232	6.41E-07	2.79E-05	1.26E-05	4.05E-05	4.75E-07	1.39E-05	1.47E-05	4.77E-05	1.58E-04
U-233	7.32E-09	4.55E-07	1.78E-07	6.50E-07	8.49E-09	1.18E-07	1.46E-07	7.22E-07	2.28E-06
U-234	1.56E-01	2.33E+00	1.40E-01	5.72E-01	3.72E-01	2.97E-02	2.08E-01	3.77E-01	4.18E+00
U-235	5.00E-03	8.00E-02	4.55E-03	1.88E-02	1.19E-02	8.44E-04	6.55E-03	1.20E-02	1.40E-01
U-238	1.62E-04	1.39E-02	1.57E-03	2.84E-02	1.33E-04	3.33E-03	3.13E-03	1.64E-03	5.23E-02

Appendix D

Adjustments to Inventory of Buried Waste from Rocky Flats Plant Based On Assay Data by Blackwood and Hoffman (2004)

Bruce H. Becker

Appendix D

Adjustments to Inventory of Buried Waste from Rocky Flats Plant Based On Assay Data by Blackwood and Hoffman (2004)

Bruce H. Becker

Blackwood and Hoffman (2004) evaluated the assay data for waste from the Rocky Flats Plant[a] (RFP) stored in the Transuranic Storage Area to validate the inventory of buried waste in the Subsurface Disposal Area (SDA); however, the evaluation is only applicable to waste buried from 1964 to 1970. Waste buried before 1964 would have a different waste loading configuration based on information compiled by Zodtner and Rogers (1964). The adjustment below uses the inventory per unit weight of waste for assayed waste streams (Blackwood and Hoffman) and the number of drums from the Waste Information and Location Database to compute an overall inventory amount. This overall inventory is then compared to the inventory developed by the Historical Data Task (HDT) (LMITCO 1995). This paper includes:

- A summary comparison of results of Blackwood and Hoffman (2004) and of HDT inventory values by waste stream, by radionuclide, for the years 1964 to 1970 (see Table D-1)
- A discussion of the differences and any recommendations for changes to the inventory for plutonium, americium, and uranium.

Plutonium

The Pu-239 inventory by waste stream is higher than the HDT inventory using Blackwood and Hoffman's (2004) data for all the waste streams assessed. Since these are the highest loaded waste streams, the implication is that the HDT significantly underestimates the amount of Pu-239 inventory in waste from RFP. However, HDT waste streams do not correspond directly to assay item description codes used by Blackwood and Hoffman. Also, because there is no direct correlation, significant numbers of curies in line-generated waste and debris waste streams are not included in Blackwood and Hoffman's data. Line-generated waste could be graphite (as shown in the retrievals made by the Glovebox Excavator Method Project[b]) or filters. In addition, more than 7,000 curies listed in waste stream RFO-DOW-10H are described as "conduit, pipes, control panels, office equipment, glass" (LMITCO 1995). The HDT is based on the material accounting records and shows 3.4E+04 curies of Pu-239, while Blackwood and Hoffman's data show 2.81E+04 for the highly loaded waste streams. Since the plutonium data are based on material accounting records, the discrepancy between the HDT and Blackwood and Hoffman's data is

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a. The Rocky Flats Plant is located 26 km (16 mi) northwest of Denver. In the mid-1990s, it was renamed the Rocky Flats Environmental Technology Site. In the late 1990s, it was again renamed to its present name, the Rocky Flats Plant Closure Project. Most of the transuranic waste in the Subsurface Disposal Area originated at the Rocky Flats Plant.

b. The Operable Unit 7-10 Glovebox Excavator Method Project retrieved 75 m^3 of buried waste from the SDA during December 2003 and January 2004 (DOE-ID 2004). The purpose of the Glovebox Excavator Method Project was to demonstrate the feasibility of waste retrieval, provide information on any contaminants of concern present in the underburden, and characterize waste zone material for safe and compliant storage pending a decision on final disposition. The Glovebox Excavator Method Project operated under the *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991) and the "Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA/Superfund)" (42 USC § 9601 et seq., 1980).

based on the mismatch in waste streams and proportioning of material in the HDT waste streams, not on inaccuracy in the total inventory.

Recommendation: Do not adjust the HDT best-estimate and upper-bound numbers as published for plutonium.

Americium

The Am-241 inventory by waste stream is higher than the HDT inventory using Blackwood and Hoffman's (2004) data for all the waste streams assessed. The HDT did not assign inventory amounts to the organic or special setup sludge from RFP; since the sludge contains less than 1% of the total Am-241, this is probably not an issue. However, the total amount listed in the HDT is roughly 35% low compared to Blackwood and Hoffman's data. Even adding in the curies in the Type I and Type V waste (see Table D-1), the HDT data are still roughly 20% low. The decay of Pu-241 in the assayed drums compared to the "as generated" HDT data can account for a fraction of the difference in Am-241 for the filters. Up to 3.E+3 Ci of Am-241 (of the total 7.5E+3) could be through ingrowth (i.e., roughly half). The Am-241 inventory in the HDT is based on a ratio to Pu-239 inventory provided in the Lee to Soule letter (1971; see Appendix G). The basis for the number in the Lee to Soule letter was not provided.

Recommendation: Use the Pu-239 to Am-241 ratio from Blackwood and Hoffman's (2004) assay data to compute the total inventory of Am-241 and adjust the best-estimate and upper-bound Am-241 inventories accordingly. The ratio is 0.066 instead of the 0.04 used in the HDT.

Uranium

The uranium in the HDT is listed in non-plutonium waste streams; one waste stream is for depleted uranium (DU) and one is for enriched uranium. Blackwood and Hoffman's (2004) assay data indicate that some DU is in plutonium-bearing waste streams. Of primary concern are the 13.9 curies of U-238 assayed in the Series 741/742 sludge (see Table D-1). The question is whether the U-238 estimated mass in the DU waste stream (RFO-DOW-16H) for the HDT includes mass assayed in the sludge, or does the HDT only account for the roaster oxide (RO) shipped from Building 444? To answer that question, three factors were considered:

- The HDT data are inconclusive. The DU inventory is based on the letter from Lee to Soule (1971; see Appendix G of the Waste Information and Location Database report) and not on material accounting records. The best-estimate number for the 3 years when RO was specifically listed appears to match the RO weight shipped. For this 3-year period, the HDT best estimate is 3.4E+01 curies (LMITCO 1995). The upper bound for that same period is 7.1E+01 curies.

- The Type A probing data do not show high Am-241 and high U-238 in the same waste (Meyer et al. 2005). This would be expected based on the assay data.

- Coring data from the 3100 m^3 Project[c] to validate Blackwood and Hoffman's (2004) data have not been available. However, calibration of assay equipment used by Blackwood and Hoffman was based on the coring data, so their numbers are assumed to be reasonable.

Recommendation: Increase the inventory of U-238 by the appropriate amount in the Series 741 sludge, and continue to research the data resulting from previous coring of sludge drums. The uranium came from a different building and different process, so scaling to the plutonium is not appropriate. The waste water from all the buildings was treated in Building 774, so it is likely that there is uranium in the Series 741 sludge. The procedure to calculate the additional uranium inventory would be to use the assay data combined with the total number of all Series 741 and 742 drums disposed of in the SDA to derive a total U-238 inventory in the SDA.

c. The 3100 m^3 Project at the Idaho National Laboratory characterized, certified, packaged, and transported contact-handled transuranic waste from the state of Idaho to the Waste Isolation Pilot Plant in Carlsbad, New Mexico. The Project met the court-approved *Idaho Settlement Agreement* milestone of having 3,100 m^3 of transuranic waste removed from the state of Idaho by December 31, 2002. The Project was started in October 1996 and was completed on September 30, 2003.

Table D-1. Comparison (in curies) between results of Blackwood and Hoffman (2004) and HDT inventory values by waste stream and radionuclide for the years 1964 to 1970.

		Pu-239				Am-241				U-238			
Waste Stream	Description	Blackwood and Hoffman	Blackwood and Hoffman Uncertainty	HDT Best Estimate	HDT Upper Bound	Blackwood and Hoffman	Blackwood and Hoffman Uncertainty	HDT Best Estimate	HDT Upper Bound	Blackwood and Hoffman	Blackwood and Hoffman Uncertainty	HDT Best Estimate	HDT Upper Bound
RFO-DOW-3H	741	5.50E+03	7.63E+02	5.14E+03	7.29E+03	9.35E+04	6.99E+03	6.58E+04	9.04E+04	1.39E+01	1.27E+00		
RFO-DOW-15H	743	1.20E+03	1.97E+02	1.58E+02	2.24E+02	2.42E+02	7.12E+01			4.26E-02	2.34E-02		
RFO-DOW-2H	744	4.24E+03	5.52E+02	1.83E+02	2.59E+02	7.13E+02	8.50E+01			—	—		
RFO-DOW-17H	745			5.82E+00	8.26E+00			6.20E+00	8.51E+00				
RFO-DOW-11H	Graphite	2.56E+03	9.79E+01	1.84E+03	2.61E+03	3.47E+02	1.40E+01			—	—		
RFO-DOW-4H	Type I			3.26E+03	4.62E+03			1.13E+04	1.56E+04				
RFO-DOW-7H	Type II			2.93E+03	4.17E+03								
RFO-DOW-6H	Type III	1.46E+04	1.81E+03	4.32E+03	6.14E+03	7.51E+03	1.63E+03	6.76E+02	9.28E+02	8.74E-03	4.56E-03		
RFO-DOW-10H	Type V			7.36E+03	1.05E+04			2.28E+03	3.12E+03				
RFO-DOW-9H	LGW			9.31E+03	1.32E+04								
RFO-DOW-16H												6.58E+01	9.90E+01
RFO-DOW-18H												1.74E-03	
Total				3.45E+04	4.90E+04			8.01E+04	1.10E+05			9.07E+01	9.90E+01

DOW = Dow Chemical

HDT = Historical Data Task

LGW = line-generated waste

RFO = Rocky Flats Operation

D-1. REFERENCES

Blackwood, L. and Cecilia Hoffman, 2004, *Descriptive Analysis of the Isotopic Composition of Selected INEEL Waste Types Using SWEPP Data*, ICP/EXT-04-00211, Idaho Completion Project.

DOE-ID, 2004, *Idaho Settlement Agreement Requirement and Milestone*, TS-ETSD-04-05, U.S. Department of Energy Idaho Operations Office.

LMITCO, 1995, *A Comprehensive Inventory of Radiological and Nonradiological Contaminants in Waste Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1952-1983*, INEL-95/0310 (formerly EGG-WM-10903), Rev. 1, Idaho National Laboratory.

Meyer, T. J., Danny L. Anderson, Carolyn W. Bishop, John R. Giles, Joel M. Hubbell, Richard L. Jones, Nick Josten, A. Jeffrey Sondrup, 2005, *Final Report for the Waste Area Group 7 Probing Project*, ICP/EXT-05-00784, Idaho Completion Project.

Zodtner, L. L. and R. F. Rogers, 1964, *Study of Unaccounted-For Plutonium Losses*, U.S. Department of Energy.

Appendix E

Fuhrman e-mail to Becker, "Improved Chlorine-36 Estimates for Bureau of Mines Disposals," 2003

INEEL

Paul Fuhrman

07/30/2003 12:53 PM

To: Bruce H Becker/HBB/CC01/INEEL/US
cc: K Jean Holdren/HJK/CC01/INEEL/US@INEL
Fax to:
Subject: Improved chlorine-36 estimate for Bureau of Mines disposals

Bruce,

As per your prior request, I reviewed the records relating to the U.S. Bureau of Mines' disposals that contained chlorine-36. The pertinent waste stream from the Historical Data Task (HDT) is stream number OFF-UBM-1H, described as "ore processing waste [includes rare earth elements (U_3O_8, Fe_2O_3, thorium oxide, uranium chlorides, and iron oxides)]". The HDT data input forms on pages OFF-165 through OFF-170 contain information regarding the disposals. The data input sheets indicate that source of the details regarding these disposals were obtained from RWIMS, the report *Buried Waste Characterization: Nonradiological Hazards Study - Offsite Waste Generators* (PR-W-80-027, section 2.2.2), along with copies of the shipping records USBM-61-1, 62-1, 62-2, 63-1, & 63-1a.

Notes on the HDT data sheets indicate that the waste stream curie content was determined by the generator's analytical methods prior to shipping. The total was about 3.1424 Ci and appears to come directly from the RWMIS entries for these five shipping records. Since no activity levels were provided for each package listed on the shipping forms, the HDT data sheets indicate that this total activity was distributed evenly among the radionuclides that were listed on the shipping forms. The activity was actually divided among each unique radionuclide chemical form (e.g., oxide, chloride, alloy, etc.), not just by isotope. The total activity assigned in part D of the HDT data sheets however, was around 2.8192 Ci, not the 3.1424 indicated from RWIMS. All radionuclide forms except for the uranium isotopes were assigned 0.3142 Ci each. It isn't readily apparent how the values for the various uranium isotopes were determined, but the total uranium content assigned was around 0.6198 Ci. No basis was given for the overall approach used for assigning radionuclide quantities to this waste stream. While the lack of specific quantities reported per radionuclide may have forced a qualitative approach to assigning quantities, this approach that was used is overly simplistic and results in significantly higher uncertainties than the +/- 50% that was indicated in the HDT data sheets. Adding to the uncertainty is the fact that no curie quantities were indicated in RWIMS for two of the five shipments and that 3.06 Ci of the 3.1424 Ci total in RWIMS is from just the 1/23/61 shipment.

Regarding the 0.31424 Ci quantity assigned to the chlorine-36, since the approach used to assign this quantity was simplistic and resulted in very large uncertainties, an improved estimate of how much of this material would realistically have been disposed of is desired. The primary evidence as to the general quantity involved comes from the chlorine-36 descriptions in the shipping records. Since our records in the Electronic Document Management System (EDMS) were not complete, I contacted Greg Slavens, a chemical engineer in the ES&H department at the DOE Albany Research Center (ARC). The ARC had been run by the U.S. Bureau of Mines and was the source for four of the five U.S. Bureau of Mines shipments. One of the shipments came from a U.S. Bureau of Mines facility in Reno, Nevada, however, this facility is no longer in existence. The shipment from Reno was the smallest shipment of the five and did not list any chlorine-36. Mr. Slavens provided me with the shipping form attachments which were missing or incomplete in the EDMS. I also asked him to see if he could find any information as to the probable use of chlorine-36, and quantities disposed of, by the ARC in the timeframe of the shipments. While the personnel who worked at the ARC at the time of the disposals have subsequently retired, he discussed this question with existing ARC personnel who he thought might have some insight. He said that he could find no evidence of a prior ARC project that would have used a major quantity of chlorine-36 and that it was most likely present as a trace contaminant in the disposals. This conclusion would appear to be backed up by the descriptions of the chlorine-36 disposals in the shipping form attachments.

Only the shipping forms with RWIMS dates 3/26/62 and 1/23/61 indicate a chlorine-36 component in the disposal. The 3/26/62 form lists chlorine-36 in three of the 16 packages described. All three descriptions

refer to trace quantities, contained in settling tank sludge, a tank, and pipe, from chemical processes. The 1/23/61 shipment lists chlorine-36 in two of the seven packages described. The two descriptions indicate disposals from the ARC Radioisotope Lab, with chlorine-36 contamination contained on waste paper and in a single HEPA filter. In addition, a June 28, 1979 letter from the ARC to Tom Clements indicates that the 1/23/61 shipment contained "possible contamination from chlorine-36 and yttrium-91". All of these references point to the chlorine-36 disposals from the ARC as being trace or contamination-level amounts. In order to estimate what a reasonable "trace" amount of chlorine-36 might be, I looked at what chlorine-36 amounts were listed for typical sources and standards available from a number of radioisotope vendors, along with typical amounts for items listed in a database containing information on radioactive sources in the DOE complex.

Since the ARC currently has chlorine-36 in the form of legacy radioactive sources and since this form is a very common use of chlorine-36, I obtained information from a radioactive source database that was put together as part of the Nuclear Materials Integration (NMI) Project conducted by the DOE-EM Nuclear Materials Stewardship Program in the late 1990's. While not totally comprehensive, the NMI team that assembled this database estimated it to contain the majority of significant source items in the DOE complex. The current version of this database listed over 300 chlorine-36 items with a total amount of 26.64 millicuries of chlorine-36. The median size of these sources was 10 microcuries, with an average of 80 microcuries, a standard deviation of 540 microcuries, and the largest single entry being 6 millicuries. Nominal activities of chlorine-36 sources and standards available from the vendors I obtained product information from ranged from 1 nanocurie to 15 microcuries.

In summary, evidence indicates that the U.S. Bureau of Mines disposals most likely contained minor amounts of chlorine-36. The 0.3142 Ci originally estimated was simplistic and grossly conservative given the "trace" or "contaminant" quantities indicated in the shipping forms and ARC correspondence, along with the fact that this amount is an order of magnitude higher than the 0.02664 curies of chlorine-36 captured in the NMI source database for the entire DOE complex. While any improved estimate for the amount of chlorine-36 will be qualitative, have significant error bars, and depend on the judgement of the person deriving the estimate, my recommendations based on the information described in this analysis are as follows:

Lower Bound = 50 nanocuries
This assumes that each of the five packages listed in the shipping form attachments as containing chlorine-36 have 10 nanocuries of chlorine-36 contamination associated with them. This assumes that "trace" amounts of chlorine-36 were disposed of and corresponds to the lower activity range of commonly available chlorine-36 radioactive sources and standards, and to the smaller chlorine-36 items listed in the NMI radioactive source database.

Best Estimate = 5 microcuries
This assumes that each of the five packages have 1 microcurie of chlorine-36 contamination associated with them. It assumes that "trace", but still relatively significant amounts of chlorine-36 were disposed of. This amount should still be slightly conservative as a "contamination" level since it basically assumes that an amount equivalent to a typical chlorine-36 radioactive source or standard, or to the median chlorine-36 item in the NMI source database, is effectively disposed of with each package.

Upper Bound = 500 microcuries
This assumes that each of the five packages have 100 microcuries of chlorine-36 associated with them. It assumes that relatively significant amounts of chlorine-36 were disposed of. This amount corresponds to the upper activity range of commonly available radioactive sources and standards and is above the average value of 80 microcuries for the items listed in the NMI source database. Note that this upper bound estimate is still roughly three orders of magnitude less than the original best estimate.

Please let me know if you have any questions regarding my data, analysis method, or recommendations.

Appendix F

Swenson e-mail to McKenzie, "WCF Filter Disposal," 2004

M Doug Mckenzie
06/17/2004 11:59 AM

To: Karen Taylor/KTA/CC01/INEEL/US@INEL, Kirk M Green/KMG/CC01/INEEL/US@INEL, Bruce H Becker/HBB/CC01/INEEL/US@INEL, Danny L Anderson/ANDEDL/CC01/INEEL/US@INEL
cc:
Fax to:
Subject: WCF Filter Disposal

This documents the information about the WCF filters for which a CPP disposal record could not be found.
----- Forwarded by M Doug Mckenzie/MKM/CC01/INEEL/US on 06/17/2004 11:55 AM -----

INEEL

Michael C Swenson
06/17/2004 09:36 AM

To: M Doug Mckenzie/MKM/CC01/INEEL/US@INEL
cc: Michael W Patterson/MPATTERS/CC01/INEEL/US@INEL, M Daniel Staiger/STAIMD/CC01/INEEL/US@INEL
Fax to:
Subject: WCF Filter Disposal

Per your question regarding WCF Filters and their disposal, here are some brief summary statements and references for them.

1. The Original WCF off-gas filters were contained in a housing that was reused. Upon filter changeout, the housing (with filters) were sent to TAN. At TAN the filter housing was disassembled the old filters removed and inspected if needed, new filters installed and the housing (with new filter) returned to ICPP. The used filters were sent to the burial ground from TAN. I do not know if the burial grounds would have these listed as a TAN item or a CPP item. It would be filters, not housing. TAN may have combined them with other wastes.
Ref. B. R. Wheeler, "WCF Filter Housings", letter Wlr-34-73, March 23, 1973, also
Ref. C. B. Amberson, "WCF Filter Housings", letter Amb-99-72, August 3, 1972, also
Ref. C. B. Amberson, "Hot Cell Costs for WCF Filters", letter Amb-32-73, May8, 1973

2. The WCF had 3 parallel filter units. There were enough filter housings to have 3 on-line filters and spares in transit/changeout at TAN. There appears to have been seven filter housings in 1972.
Ref C. B. Amberson letter 99-72 in item #1.

3. During WCF Campaign 6 (1973-1974) the WCF switched filter housings and began to use a disposable housing. From that time on, the WCF filter and its housing were changed together and the combined unit was sent to the burial grounds. This was done due to rising costs associated with filter changeouts and dradiation exposure at TAN, scheduling difficulties getting filter housing to/from TAN in a timely manner to support WCF operation, etc.
Ref. C. B. Amberson letter 32-73 in #1.

4. The original reusable filter housings were in use at the start of campaign #6 May 1973). When they were changed, they were sent to the burial grounds and replaced with disposable filter housings. Thereafter the disposable housings and filters were sent to the burial grounds. This occurred over a several month time period as filter changes typically occurred once every several weeks and there were several of the old, original housings that were used in the early part of campaign 5. Specifically, there are written reports that the first filter changeout may have occurred on June 20, 1973 and both filter and housing (old style) were sent to the burial grounds. The same thing occurred in August, with three more filters and housings were changed and sent to the burial grounds.
Ref. C. B. Amberson, "ICP Production Monthly Report No. 160 June 27 through July 26, 1973", letter Amb-45-73, August3, 1973.
Ref. C. B. Amberson, "ICP Production Monthly Report No. 160 July 27 through August 26, 1973", letter Amb-58-73, September 4, 1973.

5. Note the discussion in #4 covers 4 of the seven originally reusable filter housings. The disposition of the other three is not certain. There is some evidence that all 3 of the WCF filters were changed in May 1973. This would make sense, to start off the operating campaign with fresh filters. But I can't find that in

an official (referenceable) report/letter. I could go digging, but don't have the time right now. The monthly report for May 1973 doesn't mention filter changes. That doesn't mean they did not occur. Filter changes were routine occurrences and may not have been deemed worthy to put in the May monthly report. However, if all three were changed in May, that would be 7 total. Otherwise they would have been changed later in the October/November time frame.

Appendix G

Lee Letter to Soule, "Rocky Flats Solid Waste Shipped to NRTS [National Reactor Testing Station]," 1971

ROCKY FLATS DIVISION
P. O. BOX 833
GOLDEN, COLORADO 80401

JUN 10 '71

Mr. Harvey F. Soule
Division of Waste and Scrap
Management
U. S. Atomic Energy Commission
Washington, D. C. 20545

Thru: Mr. F. E. Abbott
Manager, RFAO, USAEC

ROCKY FLATS SOLID WASTE SHIPPED TO NRTS

Enclosed is the information that you requested on your visit to Rocky Flats on August 31 and September 1, 1970.

W. H. Lee
Environment Control Manager

JBO:sls
Enc.

cc:
F. E. Abbott - AEC, Rocky Flats
C. H. Dompierre - Dow, Rocky Flats
L. M. Joshel - Dow, Rocky Flats
J. B. Owen - Dow, Rocky Flats

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SOLID WASTE SHIPMENTS FROM ROCKY FLATS TO IDAHO FALLS, IDAHO

1954 Thru 1970

Table I is a summary of the various containers of solid contaminated waste shipped from Rocky Flats to Idaho Falls during the period of 1954 thru 1970.

The estimated quantities of radioactive materials in the wastes are given in Table II.

Transuranium contaminated waste packages bear the following building identification numbers or prefix numbers: 559---, 707---, 771---, 771 (595) ---, 741---, 742---, 743---, 744---, 745---, 746---, 776---, 777---, 779---, and 995---.

Non-transuranium contaminated waste packages bear the following building identification numbers or prefix numbers: 123---, 331---, 440---, 441---, 444---, 865---, 831---, 883---, and 889---.

We still need [illegible] of where and [illegible] numbers [illegible] packages!

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TABLE I

TYPES AND NUMBER OF CONTAINERS OF SOLID WASTES SHIPPED FROM ROCKY FLATS TO THE NTS

Calendar Year	55-gal Drums		30-gal Drums		40-gal Drums		Boxes (std)[a]		Boxes (<std)		Boxes (>std)		Filters		Cartons	
	Number	Cu Ft	Number	Cu Ft	Number	Cu Ft	Number	Cu Ft	Number	Cu Ft	Number	Cu Ft	Number	Cu Ft	Number	Cu Ft
1954	1,705	12,617	2,265	11,325					5	50						
1955	4,381	32,419	174	870	53	318			7	106			1,205	5,664		
1956	4,773	35,320	11	55	1,054	6,324			8	106			2	9		
1957	7,138	52,821	535	2,925					61	2,367	3	672	1,251	5,880	101	2,112
1958	6,096	45,110	303	1,515	43	259			131	4,073	9	1,797	1,642	4,932	123	554
1959	7,833	58,334	119	595	5	30			139	5,399	7	1,268	1,679	7,891		
1960	7,689	56,399	30	150	1	6			160	8,104	22	3,257	130	611	34	156
1961	9,566	70,788	22	110	17	102			153	5,824	12	1,850	1,392	7,450		
1962	10,752	79,565	15	75	1	6			166	9,351	34	5,692	349	2,557	7	35
1963	12,012	88,889	4	20					199	13,835	87	13,732	535	2,065		
1964	11,383	84,234	2	10					168	10,120	211	33,645	1,023	4,927		
1965	9,784	72,402							91	4,493	280	41,476	762	3,581		
1966	13,596	100,610	12	60					59	3,344	454	64,345	575	3,101	10	93
1967	18,350	135,790	3	15			1	112	32	1,519	391	51,615	990	4,980	943	11,670
1968	19,118	141,473	66	330			425	47,600	76	5,850	588	95,555	323	2,433	4,267	52,484
1969	17,564	129,974	2,855	14,275			665	74,480	30	1,611	63	14,109	209	1,328	249	3,056
1970	22,321	165,175	741	3,705			1,380	154,560	59	3,431	62	15,686	641	4,679	43	529
Totals Number	184,111		7,207		1,174		2,471		1,544		2,223[b]		12,508[c]		5,782[d]	
Totals Cu Ft		1,362,420		36,035		7,045		276,752		79,663		344,699		62,288		70,691

[a] Standard Box - 84 in. by 48 in. by 48 in.

[b] Includes 875 boxes 84 in. by 48 in. by 52 in. and 273 boxes 84 in. by 48 in. by 50 in.

[c] Includes 24 in. by 24 in. by 14 in., 24 in. by 24 in. by 16 in., 24 in. by 24 in. by 18 in., 24 in. by 24 in. by 28, and 28 in. by 28 in. by 16 in. cartons of filters.

[d] Includes 5,496 cartons containing 55-gal drums.

TABLE I

SUMMARY OF CONTAINERS OF SOLID WASTES SHIPPED FROM ROCKY FLATS TO IDAHO FALLS, IDAHO

Calendar Year	55-Gal. Drums Number	55-Gal. Drums Cu. Ft.	30-Gal. Drums Number	30-Gal. Drums Cu. Ft.	40-Gal. Drums Number	40-Gal. Drums Cu. Ft.	Boxes (Std.)* Number	Boxes (Std.)* Cu. Ft.	Boxes (<Std.) Number	Boxes (<Std.) Cu. Ft.	Boxes (>Std.) Number	Boxes (>Std.) Cu. Ft.	Filters Number	Filters Cu. Ft.	Cartons Number	Cartons Cu. Ft.
1954	1,705	12,617	2,266	11,325			23992		5	50						
1955	4,321	32,419	174	870	53	318	39377		7	106			1,205	5,664		
1956	4,773	35,320	11	55	1,054	6,324	41514		8	106			2	9		
1957	7,128	52,621	535	2,925			66777		61	2,367	3	672	1,251	5,870	101	2,112
1958	6,096	45,110	303	1,515	43	259	58240		131	4,073	9	1,797	1,042	4,932	123	594
1959	7,[illegible]	58,334	119	595	5	30	73517		139	5,399	7	1,268	1,679	7,891		
1960	7,609	56,399	30	150	1	6	69123		160	8,104	22	3,257	130	611	34	156
1961	9,566	70,703	22	110	17	102	86124		153	5,824	12	1,050	1,592	7,450		
1962	10,752	79,565	15	75	1	6	97281		166	9,351	34	5,692	549	2,557	7	35
1963	12,012	88,[illegible]	4	20			118541		199	13,835	87	13,732	535	2,065		
1964	11,333	84,234	2	10			132,776		168	10,120	211	33,645	1,023	4,927		
1965	9,[illegible]	72,402					121,952		91	4,493	280	41,476	762	3,581		
1966	13,596	100,610	12	60			171,555		59	3,344	454	64,445	575	3,101	10	95
1967	18,350	135,790	3	15		205701	1	112	32	1,519	391	61,615	990	4,980	948	11,670
1968	19,118	141,473	66	330		345,785	425	47,600	76	5,550	588	95,555	323	2,433	4,267	52,484
1969	17,564	129,974	2,855	14,275		239,033	665	74,480	30	1,611	63	14,109	200	1,528	249	3,056
1970	22,321	165,175	741	3,705		347,765	1,380	154,560	59	3,431	62	15,686	641	4,679	43	529
TOTALS Number	184,111		7,207		1,174		2,471		1,544		2,223[1]		12,508[2]		5,762[3]	
TOTALS Cu. Ft.		1,362,420		36,035		7,045		276,752		79,663		344,699		62,288		70,691

*Standard Box - 84"x48"x48"

[1]Includes - 875 Boxes 84"x48"x52" and 273 Boxes 84"x48"x50"

[2]Includes - 24"x24"x14", 24"x24"x16", 24"x24"x18", 24"x24"x28", and 28"x28"x16" Cartons of Filters

[3]Includes - 5,496 Cartons Containing 55-Gallon Drums

TABLE II

ESTIMATED QUANTITIES OF RADIOACTIVE MATERIALS SHIPPED FROM ROCKY FLATS TO IDAHO FALLS, IDAHO

Calendar Year	^{238}U Kg	^{235}U g	^{238}Pu g	^{239}Pu g	^{240}Pu g	^{241}Pu g	^{242}Pu g	^{241}Am g
1954	733	180	0.02	239.09	14.94	0.90	0.04	14
1955	979	870	0.15	1,529.26	95.54	5.79	0.26	26
1956	1,174	1,108	0.22	2,266.23	141.59	8.58	0.38	28
1957	2,147	1,616	0.30	3,184.16	198.94	12.05	0.54	43
1958	4,209	5,009	0.41	4,320.55	269.93	16.36	0.74	61
1959	3,753	11,319	0.46	4,800.61	299.93	18.18	0.82	62
1960	4,123	16,481	0.34	3,553.84	222.06	17.15	0.61	46
1961	4,311	13,921	0.53	5,538.71	346.09	26.73	0.95	70
1962	4,674	4,493	0.50	5,171.52	323.14	24.95	0.88	100
1963	1,672	6,269	1.53	15,944.51	996.30	76.94	2.72	204
1964	1,339	7,888	1.79	18,586.94	1,161.41	89.69	3.17	238
1965	4,269	4,066	2.43	25,310.54	1,583.41	122.28	4.33	414
1966	53,452	1,688	8.73	90,820.55	5,674.95	438.25	15.51	2,815
1967	53,176	1,889	5.40	56,231.01	3,513.61	271.34	9.60	2,129
1968	33,373	1,210	4.18	43,543.44	2,720.83	210.11	7.44	1,778
1969	22,721	36,259	3.25	38,046.37	2,376.93	149.34	6.49	4,875
1970	7,084	14,196	2.58	24,178.81	1,517.63	105.82	5.16	1,834
TOTALS	203,194 Kg	128,467 g	32.82 g	343,296.17 g	21,457.23 g	1,594.46 g	59.64 g	14,817 g

During calendar year 1967 there were 56 grams of ^{233}U.